ASPECTS OF THE ECOLOGY OF FERAL GOATS (CAPRA HIRCUS. L) IN THE MAHOENUI GIANT WETA RESERVE

A thesis presented in partial fulfilment
of the requirements for the degree of
Master of Science in Ecology
at Massey University

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1993

Frontispiece. Male feral goat (R7) overlooking the Mahoenui giant weta reserve (February 1993)

Abstract

A field study of feral goats (*Capra hircus*) was carried out in the Mahoenui giant weta reserve, southern King Country, New Zealand, from March 1992 to February 1993. The reserve supports the main population of the undescribed Mahoenui giant weta (*Deinacrida sp.*). The dominant woody browse plant in the reserve, gorse (*Ulex europaeus*), provides protection, shelter and food for weta. The study aimed to provide information on aspects of the ecology of feral goats to better understand their role in the reserve, and to assess any possible effects on weta survival.

The activities, foraging behaviour and broad diet of feral goats within the reserve were studied by means of direct observation and autopsies. Gorse was adequate for goat growth only during late spring/summer, and became a maintenance feed at other times of the year. Goat browsing has probably slowed down the rate of succession from gorse to native forest cover but not prevented it. Successional changes may be detrimental to weta survival.

Ranges of male and female herds overlapped at all times of the year and animals from several ranges occupied common bedding sites during the year. Feeding (grazing and browsing) was the dominant activity of adult feral goats in the reserve. Females spent more time feeding than males. Grazing and browsing changed seasonally for both sexes, with grazing generally decreasing from autumn to summer, and browsing increasing from summer to spring. In every season females spent more time grazing than males, but males browsed more than females. Greater use of browse by the bucks may be an affect of the presence of the does.

Overall goats appear to have little direct influence on weta. A possible reduction in the rate of successional change is probably the most important effect of goats in the reserve. However, in the absence of direct manipulation of the gorse, goats can not prevent succession from occurring.

Monitoring systems for the feral goat population and the vegetation community structure are recommended.

Acknowledgements

I would like to thank Dr Robin Fordham for his supervision, assistance and encouragement during this study.

Thanks also to Dr's Ian Stringer and Murray Potter for the help given and also to Dr Ed Minot for the advice on statistical matters.

I would also like to thank the DoC staff at the Te Kuiti field centre, especially Doug Toucher who shot my summer sample of goats.

I am appreciative of the effort of Roger Lentle who shot my winter sample of goats.

Thanks also to Grace Richards for her support and assistance while we were in the field.

Many thanks goes to Nagtai Rauputu for his considerable assistance which made life in the field a lot easier.

Most of all I would like to thank my parents whose support enabled all this to happen.

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General Introduction

The status of the feral goat (*Capra hircus L.*) in New Zealand has fluctuated since it was first introduced in 1773. Initially, goats were considered a valuable resource, first as food for sailors, later as a stock animal for early settlers.
But as the effects of feral populations on New Zealand's indigenous flora developed, goats came to be regarded as noxious pests. In the early 1980's their agricultural status was once again that of a valuable resource, and many feral goat populations were domesticated. The focus then, was on fibre production, although using goats for weed control and pasture improvement was also practised (Hogg et al 1992). With the crash of the goat fibre market and the subsequent increase of feral populations from abandoned animals, the goat once more became a noxious pest to be controlled and eradicated. This sentiment was the underlying spur to many studies on feral goats in New Zealand such as those on reproductive biology (Rudge 1969; Parkes 1989), diet (Mitchell 1985; Mitchell et al 1987a, 1987b), distribution and density (Parkes 1981), population dynamics (Rudge and Smit 1970), home ranges (Riney and Caughley 1959), behaviour (Rudge 1970; Alley 1991) and general ecology (Clark 1974; Rudge 1990; Brockie 1992).

The agricultural status of goats may once again be on the rise. The opportunity exists to raise the status of goat meat, and work on aspects of carcass and meat quality in goats is presently being compiled (Colomer-Rocher et al 1992; Hogg et al 1992). Also, reports by the New Zealand Dairy Goat Industry (Anon. 1992) indicate that the overseas demand for goat milk powder is so strong that the industry cannot get enough milk to capitalise on export opportunities. Research on aspects of the management of farmed feral goats has included work on behaviour (Kilgour and Ross 1980), disease and parasites (Daniel 1967; Brassington 1987), meat and fibre productivity (Kirton 1970; Croughley 1980; Colomer-Roacher et al 1992; Hogg et al 1992), and weed control (Lambert et al 1981; Clark et al 1982; Batten 1983; Radcliffe 1983, 1986; Rolston et al 1983; Batten and Alington 1985; Hill 1987; MAF 1988; Popay et al 1986; Lambert et al 1989a, 1989b, 1989c, 1989d).

Gorse, Weta and Goats

Gorse (*Ulex europaeus*) was brought to New Zealand around 1835 (Howe et al 1988) by settlers to be used both as a hedge plant and as a fodder crop for domestic stock. The spread of gorse by the early settlers was inevitably associated with the alteration of large areas of the country as the lowland forests were cleared and burnt (Hackwell 1980). Gorse soon became a problem in New Zealand and was declared a noxious weed in 1900 (Howe et al 1988). Consumption by goats of coarse woody species such as gorse can be a useful tool in managing scrub weeds. Work to date has focused mainly on the agricultural applications of this behaviour under artificial conditions of set stocking rates, set grazing areas, and use of wethers (Lambert et al 1981; Clark et al 1982; Radcliffe 1983, 1986; Rolston et al 1983;), or under laboratory situations (Alam et al 1985; Howe et al 1988; Domingue 1989; Lambert et al 1989a, 1989b, 1989c, 1989d).

At the Mahoenui reserve in the Southern King Country, the giant weta (*Deinacrida sp.*) survives in gorse covered scrub land where feral goats are common year - round. Weta probably colonised gorse when it progressively invaded remnants of the original forest cover. The gorse itself may have been introduced to the area by the members of a Lutheran mission which once stood near (<0.5km) the weta reserve on the banks of the Mokau River (Sherley and Hayes 1993). The weta now live in gorse bushes which appear to provide them with protection, shelter and food. Observations suggest that they no longer occur in the surviving remnants of native forest. Why this should be so is unclear, and little is known of the ecology and distribution of the Mahoenui giant weta. Only four populations have been identified, three of these being transfer-populations to other mainland habitats. Most known Mahoenui giant weta occur within the reserve and the adjacent farmed properties (Sherley and Hayes 1993).

Feral goats browse the gorse but the extent of browsing and its effects on weta survival are unknown. Although research on the aspects of ecology of the Mahoenui giant weta has taken place (Jowett 1991; Sherley and Hayes 1993; Richards in prep) little attention has been directed at the feral goat population and its possible ecological effects within the reserve. In order to manage the reserve successfully, not only is information required on the weta themselves but also on all flora and fauna associated with them, be they predators, competitors or habitat providers.

This study was carried out to provide some information on aspects of feral goat ecology within the Mahoenui giant weta reserve. This was done in order to better understand the role of feral goats in the reserve, and any possible effects on weta survival.

General Aims:

The general aims of this study were to;

(1) Describe and measure the state of gorse under goat browsing.

(2) Determine the ranging behaviour of male and female goats.

(3) Quantify the behaviour of feral goats, and construct activity budgets to assess any sexual and seasonal differences.

(4) Determine the percentage of gorse in the diet and to determine any aspects of their population biology.

Study Area

The study was conducted at the Mahoenui giant weta reserve, (38°35'S 174°50'E, NZMS 260, R17) on the property of Mr N. Rauputu. The reserve lies 2km North of the village of Mahoenui, about 40km South of Te Kuiti and lies between 40 - 140 m a.s.l.. The reserve occupies rolling hill-country formed from the underlying Mahoenui mudstone (22.5 m.y.) which slumps badly because of its high clay content (Thornton 1985). Soil types over the study area are Recent soils and poorly drained alluvium (Jowett 1991).

The reserve consists of 192ha covered by gorse. It is boarded on three sides by private farmland and on the fourth by the Mokau River. Access to the reserve is through the property of Mr N. Rauputu.

Introduced Animals

Feral goats were introduced into the King Country (which includes Mahoenui district) around 1910 for the purpose of blackberry control (Clark 1974, Rudge 1990). Clark (1974) reported that many King Country goats have the physical characteristics of improved strains. Throat tassels, typical of Swiss stains such as Toggenburg or Saanen were found by Clark, and are present on some goats within the study area. Mohair characteristics, such as extremely long hair (Clark 1974), are also present in some of the Mahoenui goats. Feral goats are present in the reserve year-round. They occupy the whole reserve, surrounding farmland, and adjacent forest remnants.

Domestic cattle (*Bos taurus*) were over wintered in the reserve by Mr N. Rauputu who retains grazing rights to the reserve. Although only present in high numbers (>100) during winter and spring some cattle evade mustering and are present in the reserve year-round (10 - 12 animals : N. Rauputu pers. comm.).

Vegetation

Gorse constitutes a shrub cover over much of the reserve, in places forming a

canopy up to 3m in height. Areas at the head of valleys, and along the firebreaks consist of large areas of pasture with patches of gorse. Towards the bottom of valleys and near the river gorse cover gradually increases and pasture areas decrease. In these areas the gorse canopy is virtually continuous but very open underneath with a deep gorse litter and bare ground (Lee et al 1986). Light gaps in the canopy are colonised by grasses and ferns. In some parts of the reserve native shrubs are common. Assemblages of manuka (*Leptospermum scoparium*)/kanuka (*Kunzea ericoides*) and tree ferns (*Dicksonia fibrosa*) are present in some of the valleys. Whitey wood (*Melicytus ramiflorus*) is also present in the reserve. Most of the native trees however, are well above the browse range of goats.

Native Animals

The Mahoenui giant weta (*Deinacrida sp.*) was "rediscovered" at Mahoenui in 1962 and was initially identified as *Deinacrida heteracantha* (Ballance 1988). Subsequent examinations revealed differences in size, behaviour and physical characteristics that showed it was clearly a separate, as yet unnamed species.

The Mahoenui giant weta survives solely in gorse covered scrub land, half of which (192 ha) is reserved and under the control of the Department of Conservation. The rest is privately owned and destined for conversion to grazing pasture (Sherley 1992).

Plate 1. Main observation area in the south-west corner of the Mahoenui giant weta reserve (March 1992). Note the rolling hill-country typical of the reserve and surrounding land.

Plate 2. North-west side of the Mahoenui giant weta reserve (March 1992) showing extensive gorse cover in the valley and open pasture along the firebreak (below ridge in middle distance). Note the native vegetation (tree ferns) in the centre of the picture. Modification of the habitat by gradual succession to native trees may be detrimental to weta survival (Photo : R. Fordham).

Plate 3. Feral goats grazing in the Mahoenui giant weta reserve (March 1992). These animals are part of the male and female herds that occupied the main study area in the south-west corner of the reserve. (Background : left to right - R4M (♀); R1 (♂); FM (♂); Unidentified goat; R4 (♀); Unidentified goat; Unidentified ♂; R2 (♂). Foreground : left to right - B♂; W/G♀ (obscured); 1H (♂).).

Plate 4. Feral goats in the forest remnant contiguous with the reserve (March 1992). Weta probably colonised gorse when it progressively invaded remnants of the original forest cover.

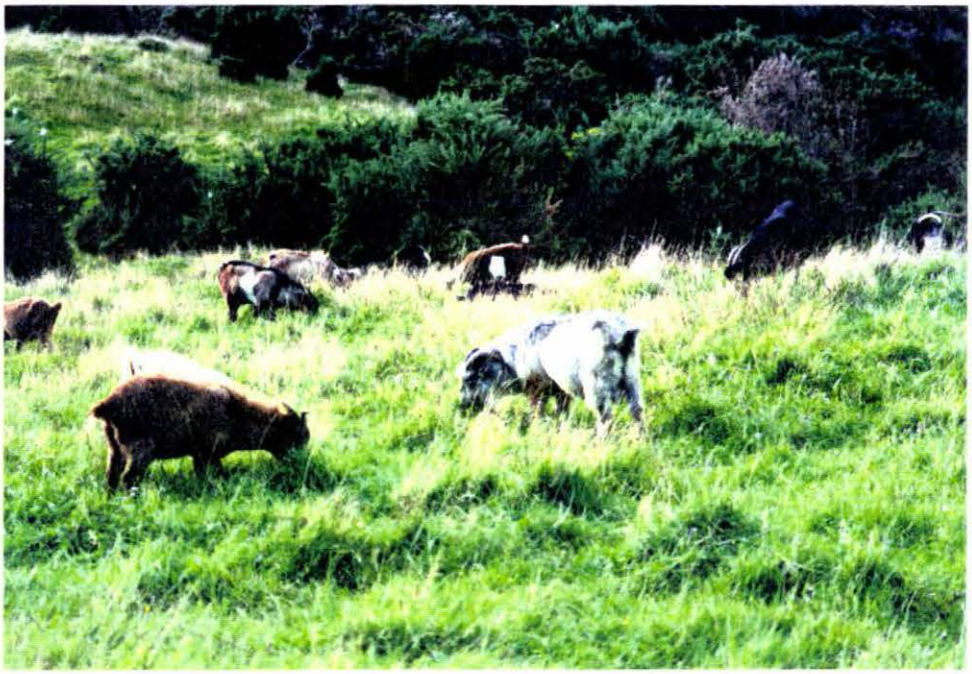


Plate 5. Mahoenui giant weta (♀) in typical defence posture. Weta were "rediscovered" at Mahoenui in 1962 and survive solely in gorse-covered scrub land (Photo : G. Richards).

Plate 6. Female Mahoenui giant weta hiding in a gorse bush during daylight. By staying in the dense middle regions of the bush the weta are protected from predators and undisturbed by goat browsing (Photo : R. Fordham).

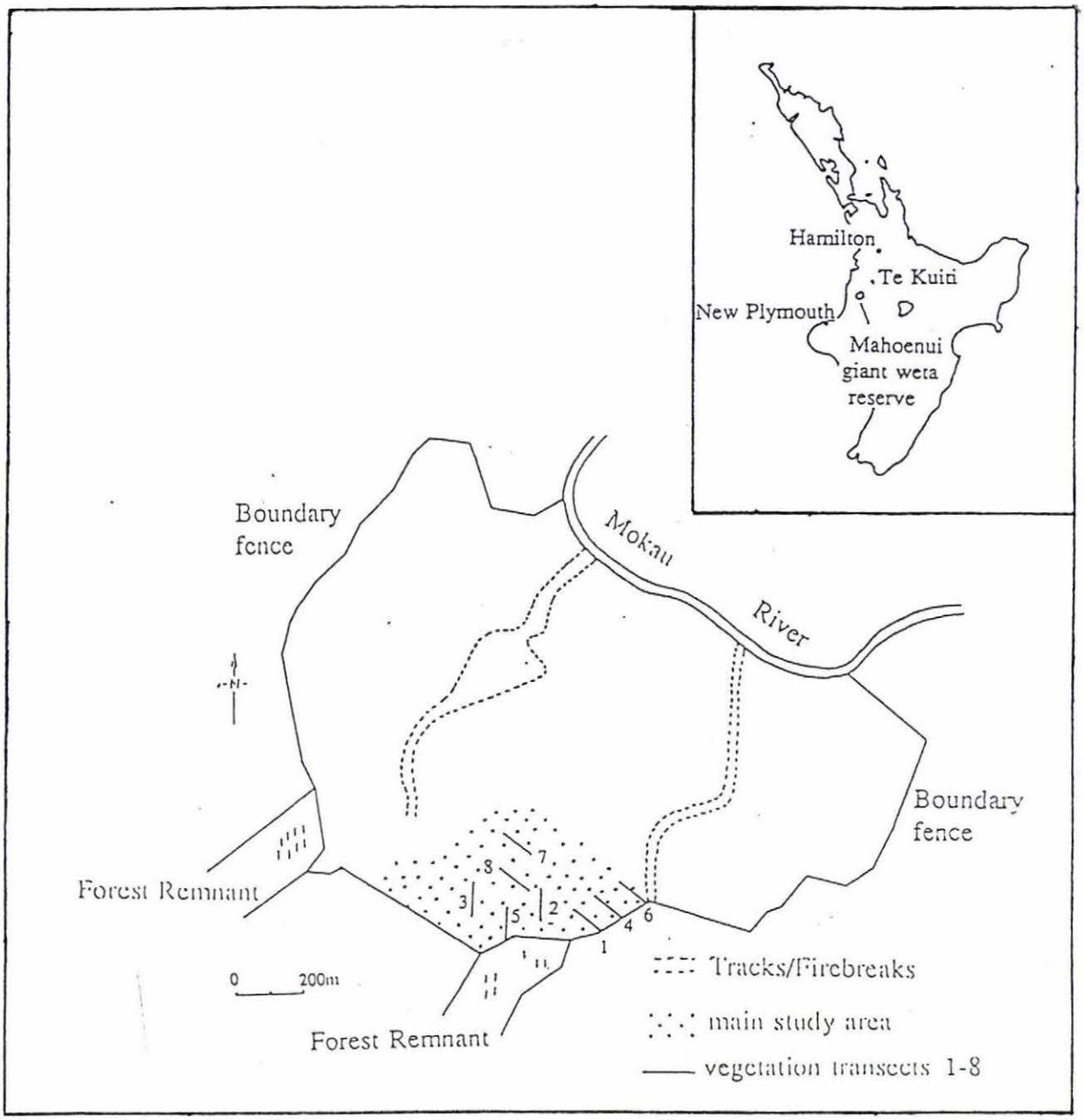


Figure 1.1 Location of Mahoenui giant weta reserve and boundaries, main study area and vegetation transects (adapted from Sherley and Hayes 1993).

Chapter 1
Gorse Habit and Nutrient Content

1.1 Introduction

Gorse (*Ulex europaeus*) is a leguminous shrub that was introduced Zealand from the British Isles around 1835 (Howe et al 1988). It was regar by the early settlers as a stock fodder and was used extensively for stock-pr and shelter (Radcliffe 1986).

Gorse is now recognised as a noxious weed in New Zealand and extensive literature on its eradication and control (Gaynor and MacCarter 19 may, however, have a useful function in biological conservation as a pionee successional species (Lee et al 1986), because it colonises bare eroded providing a seedbed and nursery for native shrubs and trees (Hackw Nonetheless gorse remains a problem, and some farmers run goats on land cc gorse and other scrubweeds to exercise control at acceptable levels. At Mah feed on the gorse, however, their present density (1-2/ha) is probably too l much effect.

The aim of this chapter is to;

(a) Describe and quantify the state of the gorse under goat browsing,

(b) Assess the structure of the gorse community, and

(c) Obtain an index of the nutritional value of gorse as feed for goats

1.2 Methods

1.21 Vegetation Transects

Vegetation data were collected by means of eight transects, each tr 100m long with stations at 2m intervals. Figure 1.1 shows the positions of th within the study area. Transects were spaced so as to widely sample the area majority of goats were observed.

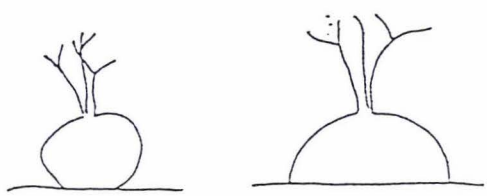
Gorse bushes were categorised into browse types according to their and amount of obvious goat browsing (Fig. 1.2 and plates 7 - 9). At each st

Type 0. Pasture

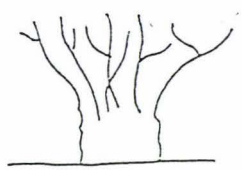
Type 1. Small unshaped

Type 2. Low dense bush shaped strongly - no top

Type 3. Low dense bush shaped strongly - with top



Type 4. Large open bush shaped slightly - with top



Type 5. Very large open bush unshaped

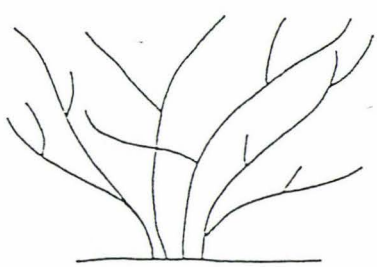


Figure 1.2. Types of shaped (goat-browsed) gorse bushes in the Mahoenui giant weta reserve.

Plate 7. Small, unshaped (type 1) gorse bushes in the Mahoenui giant weta reserve.

Plate 8. A typical type 2 gorse bush - low, dense, shaped strongly with no top, in the Mahoenui giant weta reserve.

Plate 9. A type 3 gorse bush in the Mahoenui giant weta reserve characterised by a low, dense, strongly shaped appearance and a top that is above the browsing range of goats. Note the larger, open bushes (types 4 and 5) in the background.

Plate 10. Effect of feral goat browsing on gorse in the Mahoenui giant weta reserve. The majority of bushes in the photograph are type 2, with some type 3 (top right), and types 4 and 5 (top left) present. Although the effects of goat browsing are marked in this photograph, only a small percentage of the bushes in the reserve showed such severe modification due to browsing (Photo : R. Fordham).

the transect the vegetation type was recorded as either pasture or gorse. Every gorse bush scored was assigned to the appropriate browse type. Large individual bushes that overlapped two stations were recorded only once.

1.22 Nutritional Value

Gorse foliage was collected twice for analysis of nutrient content - in June 1992 when it was hard and sharp with little or no new growth and again during February 1993 when plentiful soft new shoots had appeared. Samples of foliage were taken from within the browse range of goats (up to 1.5m), placed in ice, and carried to the laboratory where they were frozen. The material was later prepared for analysis by oven drying at 65°C for approximately two weeks, and then grinding in a Glen Creston micro hammer mill to a powder.

Analysis was carried out by R.J. Hill Laboratories in Hamilton. Nitrogen concentration was determined by the Kjedahl method. The remaining eleven elements tested were determined from nitric-perchloric acid digestion (R. Hill pers. comm.).

1.3 Results

1.31 Vegetation Transects

Figures 1.3 and 1.4 show the data collected from the eight vegetation transects. Gorse is the major component of the vegetation recorded in the study area making up 58% of the total (Fig. 1.4). 54% of the gorse bushes sampled were affected by obvious signs of goat browsing.

The majority of gorse bushes are types five and four with the abundance decreasing through types three and two. Type one occurred the least often (Fig. 1.4).

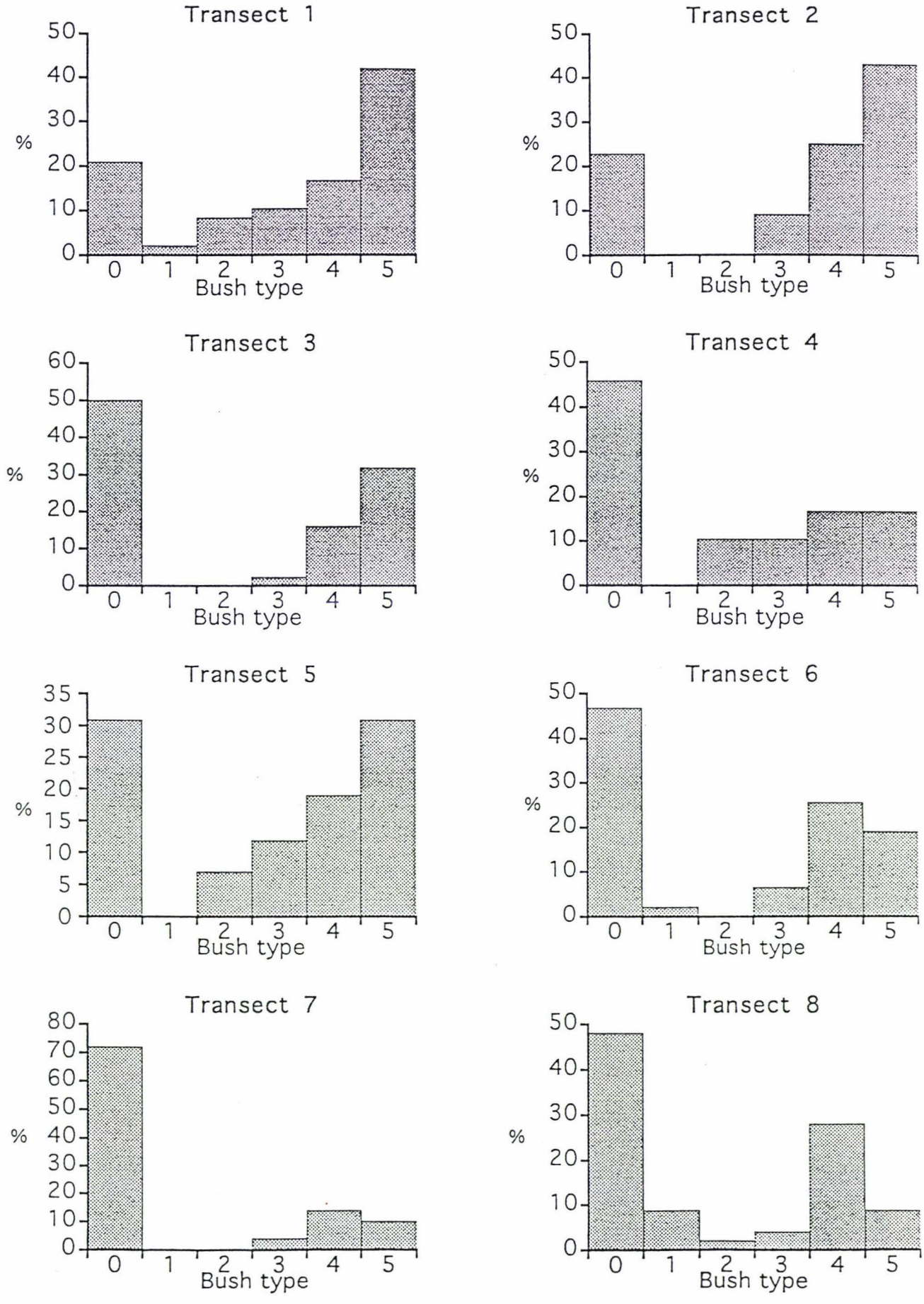
The relative abundance of each bush type and the amount of pasture varied between transects (Fig 1.3), and may reflect the amount of use an area receives.

1.32 Nutritional Value

Tables 1.1 and 1.2 show the chemical composition of gorse sampled at Mahoenui during winter and summer and its comparison with chemical compositions obtained in other studies.

The sample collected at Mahoenui during summer showed higher chemical concentrations than that taken in winter, which is consistent with other studies.

Knowledge of the requirements of goats for major and trace minerals is still fragmentary (Kessler 1991), but goats are probably similar to sheep (Grace 1983b: in Mitchell 1985). Assuming that this is so, P levels at Mahoenui were lower than that recommended for sheep, and S levels were marginally deficient for animal production.



. Figure 1.3 Percentage of each gorse bush type (1-5) and pasture (type 0) for each vegetation transect.

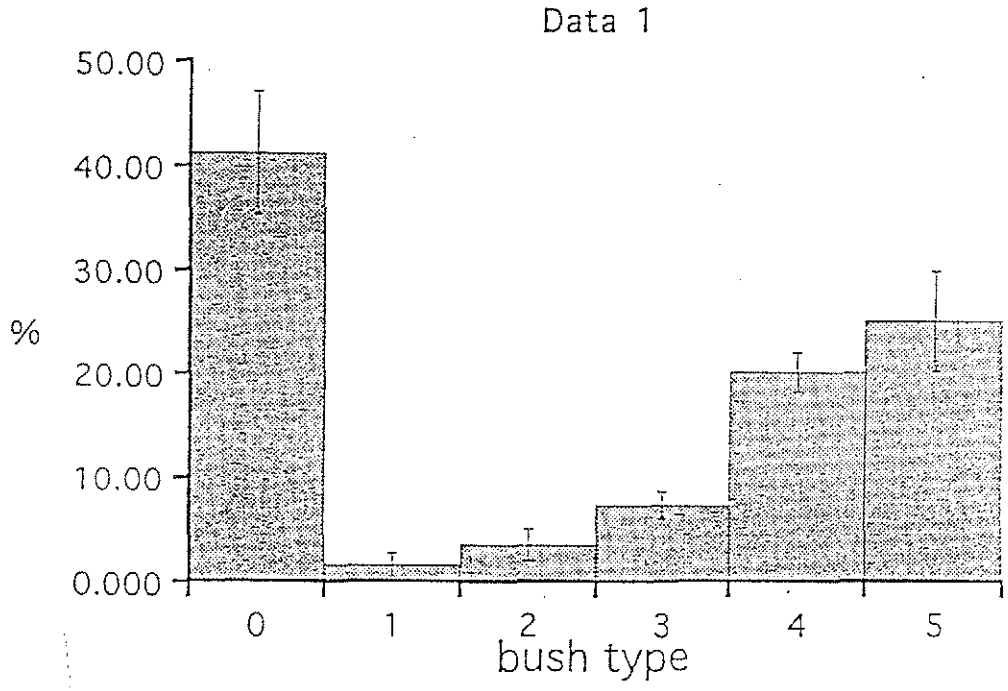


Figure 1.4. Mean percentage of each bush type (1-5) and pasture (type 0) for the eight vegetation transects combined.

Source	macro-elements N	P	K	S	Ca	Mg	Na
Egunjobi (1971)(a)	1.6	0.07	0.7	0.14	0.34	0.22	0.13
Radcliffe (1986)							
winter (b)	1.74	0.06	0.65	0.09	0.26	0.14	-
summer	2.7	0.12	1.0	0.14	0.6	0.26	-
Howe et al (1988)							
winter	4.0	0.17	1.7	0.25	0.74	0.34	0.34
summer	4.8	0.32	3.1	0.24	0.69	0.48	0.5
Lambert et al (1989d)(c)	1.8	0.1	1.0	0.13	0.31	0.13	0.26
This study							
winter	1.7	0.11	0.8	0.12	0.34	0.22	0.14
summer	3.1	0.3	1.8	0.18	0.51	0.3	0.24
Recommended(d)	1.7	0.18	0.4	0.13	0.17	0.1	0.05

(a) Values are means across all seasons.
(b) Values are means over two years.
(c) Values are means across three seasons.
(d) Recommended level for adequate diet for lactating ewe with a single lamb (Grace 1983 - in Lambert et al 1989d).

Table 1.1. Macro-element chemical composition of gorse in the Mahoenui giant weta reserve in winter (June 1992) and summer (February 1993) compared with other studies. Units are % DM.

Source	micro-elements Cu	Fe	Mn	Zn	B
Howe et al (1988)					
winter	5	174	90	34	-
summer	6	62	84	36	-
Lambert et al (1989d)(a)	4	89	59	44	-
This study					
winter	5	67	124	26	8
summer	8	59	71	44	14
Recommended(b)	4.4	30	25	24	-

(a) Values are means across three seasons.
(b) Recommended level for adequate diet for lactating ewe with a single lamb (Grace 1983 - in Lambert et al 1989d).

Table 1.2. Micro-element chemical composition of gorse in the Mahoenui giant weta reserve in winter (June 1992) and summer (February 1993) compared with other studies. Units are mg/kg DM.

1.4 Discussion

1.41 Vegetation Transects

Although the effects of goat browsing on gorse can be quite marked (plate 10) only a small percentage of the bushes in the reserve showed severe modification due to browsing. Of the five bush types recognised only types three, four and five were extensively used by weta (G.Richards pers. comm.). Most weta are found within the goat browse range and in the dense middle region of the bushes shaped by goat browsing (Sherley and Hayes 1993). Because weta hide in this dense middle region they are unharmed by goat browsing during the day. At night weta come out to the edge of the gorse bushes to feed. No night observations of goat activity were undertaken at Mahoenui so it is unknown if, and to what extent, any night feeding by goats occurred. Even though goats were observed to bed down in a location at night and arise from the same place in the morning, they could be heard moving around during the night. Alley (1991, and pers comm.) observed during night time observations in late autumn, that some captive feral goats feed for short periods of time before resuming resting. Kilgour and Ross (1980) observed no goat feeding at night while Brindley et al (1989) found feeding occurred throughout the night for the goats they studied in Great Britain. It is possible that during summer when night time temperatures are still high goats could feed during the night. If goats did feed at night there is the possibility that they could accidently consume or damage weta sitting on the vegetation. However, no weta, or any invertebrate remains were found in the rumen samples collected (see chapter 4).

The age structure of the gorse in the reserve is unknown because there is no satisfactory agreement between bushes of known ages and their ring counts (Sherley and Hayes 1993). However types four and five, the mature plants, can live for thirty years or more (Lee et al 1986). Recruitment of young gorse plants into the community is slight as shown by the small number of seedlings (type 1) recorded on the vegetation transects. Ivens (1978) found that in uncleared gorse, although moderate numbers of seeds germinated, a large proportion of seedlings died and the growth of the remainder was reduced. Lee et al (1986) found high seedling densities in stands where vegetation had been cleared recently. Seedling density was lowest in the 6-10 year age class, but increased steadily with the age of the stand. Goat browsing is unlikely to affect seedling

numbers. Rolston and Sineiro-Garcia (1974) found that while defoliation of gorse plants reduced dry matter production, seedlings generally survived such treatments. In any event gorse seed remains viable in the soil for up to thirty years (Moss 1959) so there is plenty of potential in the seed bank to replace fallen senescent bushes.

Lee et al (1986) proposed that on an undisturbed site it would take only 50-60 years for gorse to be replaced by native tree species. Goats may impede the emergence of native tree seedlings in the reserve but probably would not prevent it, because of their low population density (1-2/ha). At this density goats would not even be able to keep gorse growth static (Batten 1984) and succession is likely to occur. Indeed, in some parts of the reserve native shrubs are fairly common, and in the southern-most valley assemblages of very large old gorse, manuka/kanuka, tree ferns and rough pasture are present (Jowett 1991). Even in the areas where gorse dominates, a few native species, such as tree ferns and Poataniuha (*Melicope simplex*), have emerged.

If gorse is important for weta survival then modification of the habitat through succession to native trees may be detrimental to weta survival. Planned disturbance, such as mechanical clearing, would favour the establishment of dense young gorse and prolong the dominance of the species (Lee et al 1986). It may, therefore, be beneficial to weta to fell some of the gorse thus stimulating seedling growth and slowing successional change towards a cover of native species.

The frequency of the different types of gorse bushes varied between transects, however there was no correlation between the bush types suitable for weta, and the intensity of browsing by goats (see chapter 3) in the areas sampled by the transects. Most type 2 and 3 bushes occur in or alongside areas that have been cleared of gorse (eg. farm tracks). In these areas goats have been able to maintain a browsing pressure on the bushes, preventing them from adding sufficient height to escape their browse range.

1.42 Nutritional Value

Gorse was collected during winter when it was hard and sharp with little or no new growth, and again during early summer when new terminal spines were being formed and the foliage was soft and pliable. It is at this time that gorse is most digestible and nutritious (Radcliffe 1986 : Tables 1.1 and 1.2).

Howe et al (1988) found that gorse harvested in the Manawatu during early summer had mineral concentrations that were likely to be adequate for the requirements of growing animals. However, as the gorse matured, low concentrations of P, S and N could be limiting. Radcliffe (1986) examined the nutritive quality of gorse in Canterbury. Levels of nitrogen, calcium and molybdenum were sufficient for goat nutrition, but levels of sulphur, potassium, copper, magnesium and particularly phosphorus were low. Levels of nitrogen in mature foliage were adequate to maintain goat condition but levels sufficient for goat growth occurred only in spring and early summer. Lambert et al (1989d) found in their study, conducted in the Manawatu, that mineral concentrations, especially P, were low and concluded that gorse could not be considered as more than a maintenance feed for goats. In practice the low P content of gorse would most likely not be a problem because animals would be able to supplement browse with pasture containing higher levels of P.

Because gorse starts growing later than pasture plants, and finishes earlier (Anon 1989) gorse is an unsuitable feed for reproductive goats. Does in late pregnancy or early lactation have high nutritional requirements, as do growing kids. Poor kidding percentages are inevitable if does have a diet consisting mainly of weeds during mating and pregnancy. Also, young kids will grow slowly due to poor milk production by their mothers (MAF 1988).

Most female goats at Mahoenui are pregnant and lactating in autumn and winter when gorse is not very nutritious and is essentially a maintenance feed. Accordingly any does dependent on gorse at this time would not be expected to do well. Macferson (1993) noted, however, that protein (or N) in pasture is higher than that required by lactating does during autumn, winter and spring. Therefore in order to meet their reproductive demands during pregnancy and lactation does would need to consume pasture in preference to gorse (see chapter 3).

At Mahoenui the male goats increased the amount of gorse they ate during winter and early spring (see chapter 3) when nutritionally it is poorest. However they were often observed to consume the flowers which have higher mineral concentrations than the green foliage (Radcliffe 1986). Giant weta also feed on the gorse foliage and flowers (Sherley and Hayes 1993) so a dietary overlap occurs between weta and goats.

Goats are more selective feeders than cattle and sheep and tend to select a diet

containing a higher proportion of green leaves and a lower proportion of stem and dead materials (Flachowsky and Tiroke 1993). Goats also show a superior utilisation of low quality forage than other ruminants such as sheep (Alam et al 1985 : Domingue 1989). Even so, gorse could be considered adequate for goat growth at Mahoenui only during late spring / early summer when new growth occurs.

Chapter 2

Home Range

2.1 Introduction

A home range is the area used by an animal during its normal day-to-day activities (Sanderson 1966; O'Brien 1984; Grant et al 1992), and must be large enough to provide an adequate supply of resources. Most goats are relatively sedentary, occupying home ranges which vary according to sex and season (O'Brien 1988), with males tending to occupy larger home ranges than females (Riney and Caughley 1959; Sanderson 1966; O'Brien 1988; Rudge 1990).

A knowledge of an animal's home range is important from the standpoint of control and management (Sanderson 1966; O'Brien 1984), because the characteristics of the home range influences an animals behavioural activities. The aim of this chapter is to compare the ranging behaviour of male and female feral goats in the Mahoenui giant weta reserve and to analyse any variation between the sexes.

2.2 Methods

Observations were carried out from February 1992 to February 1993 and were restricted mainly to those goats that occupied the south-west side of the reserve. To aid in observations, coat patterns of twenty-one individuals were recorded, as outlined by Riney and Caughley (1959). These known individuals were used to determine the ranging behaviour of the goats in the study area. Home range analysis was restricted to individuals with distinctive coat patterns within one male herd and one female herd. Data collected on animals adjacent to these herds were discarded because only one individual had distinctive coat patterns and could be easily identified. Even though numbers in the adjacent herds remained the same, and therefore were almost certainly the same individuals, no such assumption was made. These data, however, were used to determine range overlap.

Seasonal home ranges were calculated by the minimum convex polygon method and involved drawing a polygon around the extremities of the observed locations (Flowerdew 1976; Chapman et al 1993; Pienaar et al 1993). Seasonal variation from the annual mean was calculated, along with their standard errors, to compare seasonally-

induced shifts in range size within each herd. The seasonal range size of male and female herds were compared with a Mann-Whitney 2-sample test to detect any sex related differences (Zar 1974).

2.3 Results

The average seasonal range for males varied from 5.06 to 5.68 ha with a mean of 5.5 ± 0.3ha (Table 2.1). Figure 2.1 suggests a significant difference in range size between spring and autumn/winter but not between any other seasons. For the females the average size of the seasonal range varied between 4.0 and 5.2ha with a mean of 4.6 ± 0.6ha. Figure 2.1 suggests a significant difference in the range size between spring and summer/autumn but not between any other seasons

Both males and females occupied overlapping ranges during all seasons (Fig. 2.2). No significant difference in the mean range size for males and females was found during spring, summer and autumn (P=0.005 n=11), but a significant difference did occur during winter (P=0.05 n=11). Both male and female herds had overlapping ranges with neighbouring herds (Fig. 2.3) and animals from different herds were often seen feeding together in the same clearings. They also shared common bedding sites.

Animal	Sex	Autumn No. observations	Range size
R1	♂	196	5.8
R1.5	♂	177	5.9
R2	♂	188	6.0
R7	♂	256	5.5
1H	♂	167	5.6
Mean ± 1sd			5.76 ± 0.21
R4	♀	197	6.0
R4M	♀	216	6.1
RX	♀	127	4.4
R3	♀	73	4.7
W/G♀	♀	172	4.9
M?	♀	81	4.0
Mean ± 1sd			5.0 ± 0.86
		Winter	
R1	♂	164	5.7
R1.5	♂	246	5.5
R2	♂	229	5.7
R7	♂	249	5.9
1H	♂	151	5.6
Mean ± 1sd			5.68 ± 0.15
R4	♀	18	3.5
R4M	♀	122	2.8
RX	♀	128	5.1
R3	♀	64	5.0
W/G♀	♀	94	4.6
M?	♀	143	5.0
Mean ± 1sd			4.3 ± 0.96

Table 2.1a Seasonal range size (ha) for individual goats at the Mahoenui giant weta reserve.

Animal	Sex	Spring No. observations	Range size
R1	♂	231	4.9
R1.5	♂	364	5.1
R2	♂	305	5.2
R7	♂	212	5.2
1H	♂	271	4.9
Mean ± 1sd			5.06 ± 0.15
R4	♀	68	4.0
R4M	♀	249	4.1
RX	♀	237	3.8
R3	♀	123	3.1
W/G♀	♀	179	4.5
M?	♀	262	4.4
Mean ± 1sd			3.98 ± 0.50
		Summer	
R1	♂	143	6.9
R1.5	♂	191	6.4
R2	♂	203	4.9
R7	♂	194	5.5
1H	♂	143	3.9
Mean ± 1sd			5.52 ± 1.19
R4	♀	0	-
R4M	♀	0	-
RX	♀	197	6.9
R3	♀	186	3.4
W/G♀	♀	169	6.0
M?	♀	166	4.4
Mean ± 1sd			5.2 ± 1.6

Table 2.1b Seasonal range size (ha) for individual goats at the Mahoenui giant weta reserve.

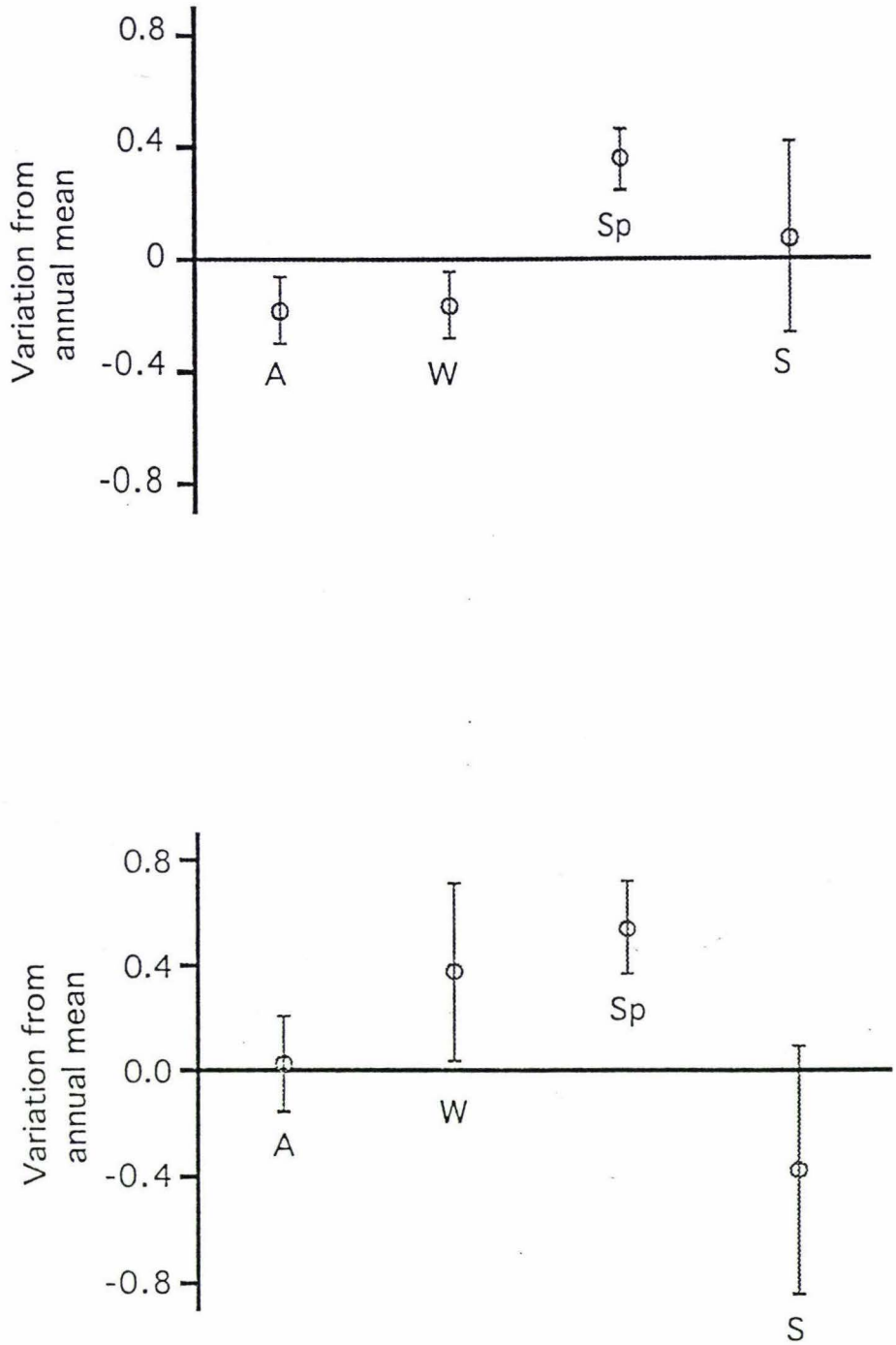


Figure 2.1. Seasonal variation from the annual mean for male (top) and female (bottom) feral goats in the Mahoenui giant weta reserve (March 1992 - February 1993). Autumn (A), Winter (W), Spring (Sp) and Summer (S).

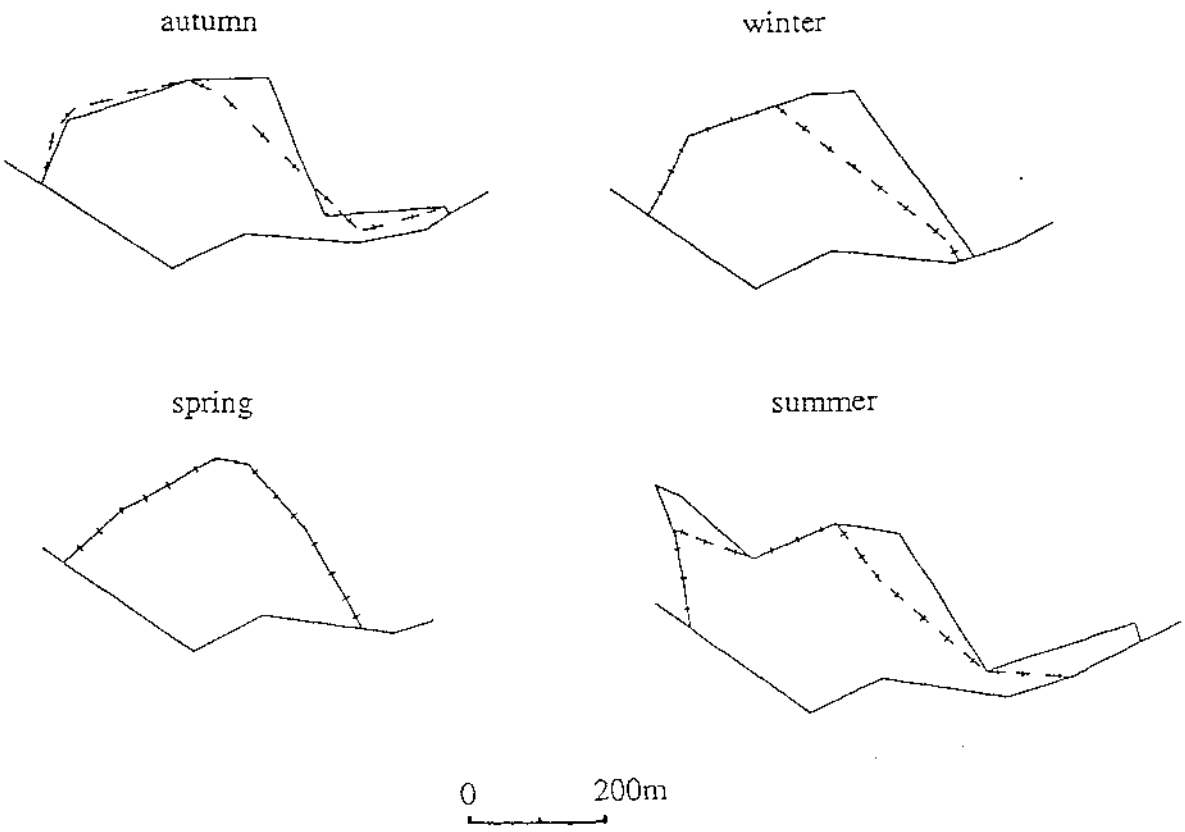


Figure 2. 2. Annual range boundaries of male and female feral goat herds in the south-west corner of the Mahoenui giant weta reserve (March 1992 - February 1993), showing the range overlap between the two sexes. —— combined male range (R1, R1.5, R2, R7, 1H); -+ -+ combined female range (R4, R4M, RX, R3, W/G♀, M?).

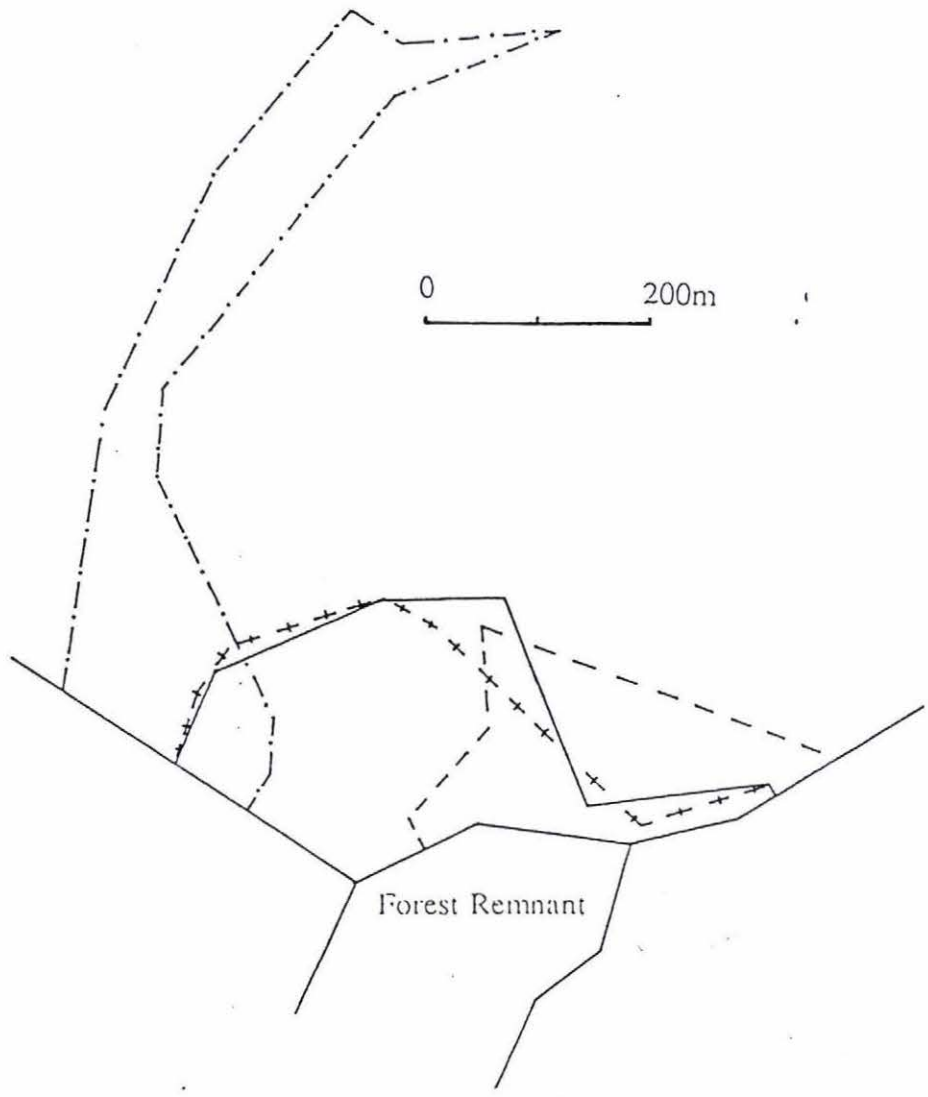


Figure 2.3. Range boundaries of four (2♂ and 2♀) feral goat herds in the south-west corner of the Mahoenui giant weta reserve (autumn 1992), showing the range overlap between neighbouring herds. —— combined male range (R1, R1.5, R2, R7, 1H); -+- combined female range (R4, R4M, RX, R3, W/G♀, M?); – – – RZ; —·— RY.

2.4 Discussion

Measures of the home ranges of five bucks and six does show that there is a large area jointly occupied by all these goats (Fig.2.2). Most studies (with some exceptions Shank 1972)) have observed that bucks disassociate from the female herd during winter to form bachelor herds (Riney and Caughley 1959; McDougall 1975; O'Brien 1988; Dunbar et al 1990; Rudge 1990; Alley 1991). No such separation into distinct male and female ranges occurred at Mahoenui, but segregation occurred to some degree. The males did form bachelor herds, but because males and females occupied the same ranges they sometimes fed or rested together in the same clearings. However both groups tended to remain discrete when they moved about the range.

Range size reflects the needs of the individual to obtain adequate resources. The greatest variability in ranges for both male and female goats occurred in summer (Fig. 2.1). At this time males enter the rut and compete for access to females. Depending on their success and the level of competition, some males have to roam further than others. The size of the range in autumn, winter and spring probably reflects the area required to obtain adequate food, rather than desired breeding encounters, because most females conceived during summer (see chapters 3 and 4). During spring, when new plant growth appeared, males and females occupied their smallest ranges in the year. Both sexes were apparently able to acquire adequate resources from these reduced ranges and did not travel more widely.

The difference in range size between the sexes during winter ($P=0.05$ $n=11$) is likely to be a result of females kidding at this time. Table 2.1 shows the range size for the six known individual females during winter. Three out of the six females (R4; R4M; W/G) kidded at the beginning of winter, and these three had the smallest range sizes for this season. Females with new kids were observed to not travel as far during the day as those without kids or those with older kids. One female (R4M) was observed to remain in the same vicinity for 4-5 days when first observed with her kid. Does that are about to give birth become solitary, and after birth may hide their kids while foraging (Rudge 1990). The length of this lying-out phase can be highly variable. Also the length of isolation before the mother-kid pair begins to integrate socially with other goats is

variable (O'Brien 1988). Until the mother-kid pair becomes more sociable and mobile, the range size would be reduced, accounting for the differences recorded.

The ranges of neighbouring groups of goats overlapped (Fig. 2.3) and animals from neighbouring ranges fed together in the same clearings with no signs of antagonism. Riney and Caughley (1959) observed that goats drift away from, or move into, associations without any observable sign of recognition or of any antagonism. They apparently recognise and accept neighbouring goats with which they are temporarily and intermittently associated. However, the entrance of new goats into the area did cause some concern to the resident goats, which showed extreme curiosity, but without any associated aggressive behaviour (Riney and Caughley 1959). Alley and Fordham (in press) found that social interactions between herd members and completely unknown new entrants was most intense during the first hour following introduction and then decreased rapidly, with the new entrant being accepted by the herd in as little as twenty four hours. The herds at Mahoenui, however, are not experiencing first-time encounters during this range overlap, and no obvious signs of the social interactions reported by Alley and Fordham (in press) were observed when the two groups meet.

Within the range bedding sites are important fixed points (Coblentz 1978; O'Brien 1984, 1988) that change seasonally. From late spring until autumn, several areas in the reserve were utilised as bedding sites by goats from surrounding ranges. Over this time the animals gathered in one location at night (Fig. 2.3), and during summer 40-60 goats could be observed to gathered at the one site. Coblentz (1978) found that the heavy use of such areas soon damages the vegetation, and that serious erosion often begins in the vicinity of traditional bedding sites. This effect was marked at Mahoenui (Plate 11). During winter, however, none of these traditional bedding sites was used and the goats bedded down in their ranges. The location of these varied, depending on where they were feeding when darkness fell.

Plate 11. Male feral goats resting at one of the bedding sites in the Mahoenui giant weta reserve (February 1993). Males were generally the last to leave a bedding site each day. The heavy use of such sites soon damages the vegetation and serious erosion can begin in the vicinity of traditional bedding sites.

Chapter 3
Activity Budgets

3.1 Introduction

The daily activities that every animal carries out are mostly concerned with maintenance and survival - grazing, browsing, ruminating, resting, walking, defecating and urinating. Some activities show distinct diurnal trends, however, all activities are linked into a changing daily pattern (Arnold and Dudzinski 1978). Animal behaviour is influenced by a number of factors, including feed availability and quality, weather, season (Arnold 1984) and photoperiod (Deveson et al 1992). Activity patterns of a species are a fundamental aspect of its interaction with its environment and therefore are important from a farming and ecological perspective (Alley 1991).

The aim of this chapter is;

(a) To describe the activity patterns of feral goats in the Mahoenui giant weta reserve,

(b) To determine the amount of feeding that occurs, and

(c) To record any sexual and seasonal variations in goat feeding.

3.2 Methods

Data were collected as outlined in Chapter 2. During each scan the activity of every visible goat was recorded, whether or not the animal was known as an individual. Following Alley (1991) observed behaviour was classified as follows:-

Grazing (stationary and moving)

Browsing

Resting (lying and sitting)

Standing

Walking (not associated with feeding)

Maintenance Behaviour (mutual grooming, self grooming or grooming against inanimate objects. Urination not associated with sexual activity)

Agonism

Other (including nursing and sexual behaviour).

The observations from twelve scans per hour were pooled, and for each month data from different days were combined for successive hours after sunrise. Monthly results were then grouped by season as follows: autumn (March-May); winter (June-July); spring (September-November); summer (December-February).

3.3 Results

The results are based on 31,735 animal observations between February 1992 and February 1993. Of these 15,859 (49.97 %) concerned males and 15,876 (50.03 %) females. Overall feeding (grazing and browsing) was the dominant activity (48.5%) (Table 3.1). Females spent more time feeding than males (53% and 44% respectively) (Table 3.1).

Females spent the same proportion of time foraging each day through autumn and winter until mid/late spring, when their foraging decreased to a low level before slowly increasing again through summer. The same general foraging pattern was observed in males but the decline through winter lasted until mid summer before any increase was observed (Figs. 3.7 and 3.8).

Overall females grazed more than males, and males browsed more than females. Resting was the second most important activity after feeding, and when combined with standing, males spent more time in this activity than females. There was little or no difference between the sexes in the remaining activity classes (Figs. 3.2-3.5).

3.31 Grazing

Males spent 31% of their time grazing, with marked seasonal changes. Grazing was greatest in autumn (49.5%) and declined steadily through winter (39%) and spring (23.5%) to a low of 20.5% in summer (Fig. 3.1). Grazing during the day was bimodal from autumn to spring, with only a single peak in mid/late afternoon during summer (Figs. 3.2-3.5).

Overall females spent 47% of their time grazing, which was constant during autumn and winter (57% and 58% respectively) before decreasing and levelling out

Activity	Male	Female	Average Total
Feeding	44.0	53.0	48.5
Resting	28.0	25.5	26.8
Standing	15.5	10.0	12.8
Walking	8.5	8.0	8.2
Maintenance	2.7	2.7	2.7
Agonism	0.8	0.3	0.5
Other	0.5	0.5	0.5
Total	100.0	100.0	100.0

Table 3.1. Percentage of time spent in each activity by male and female feral goats from March 1992 to February 1993 (n= 31 735 : male 15 859 , female 15 876) in the Mahoenui giant weta reserve.

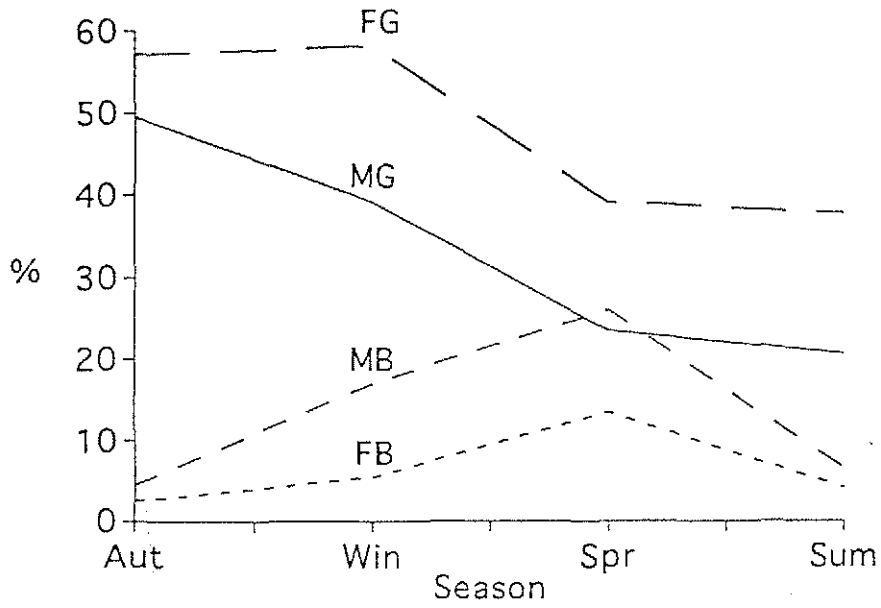
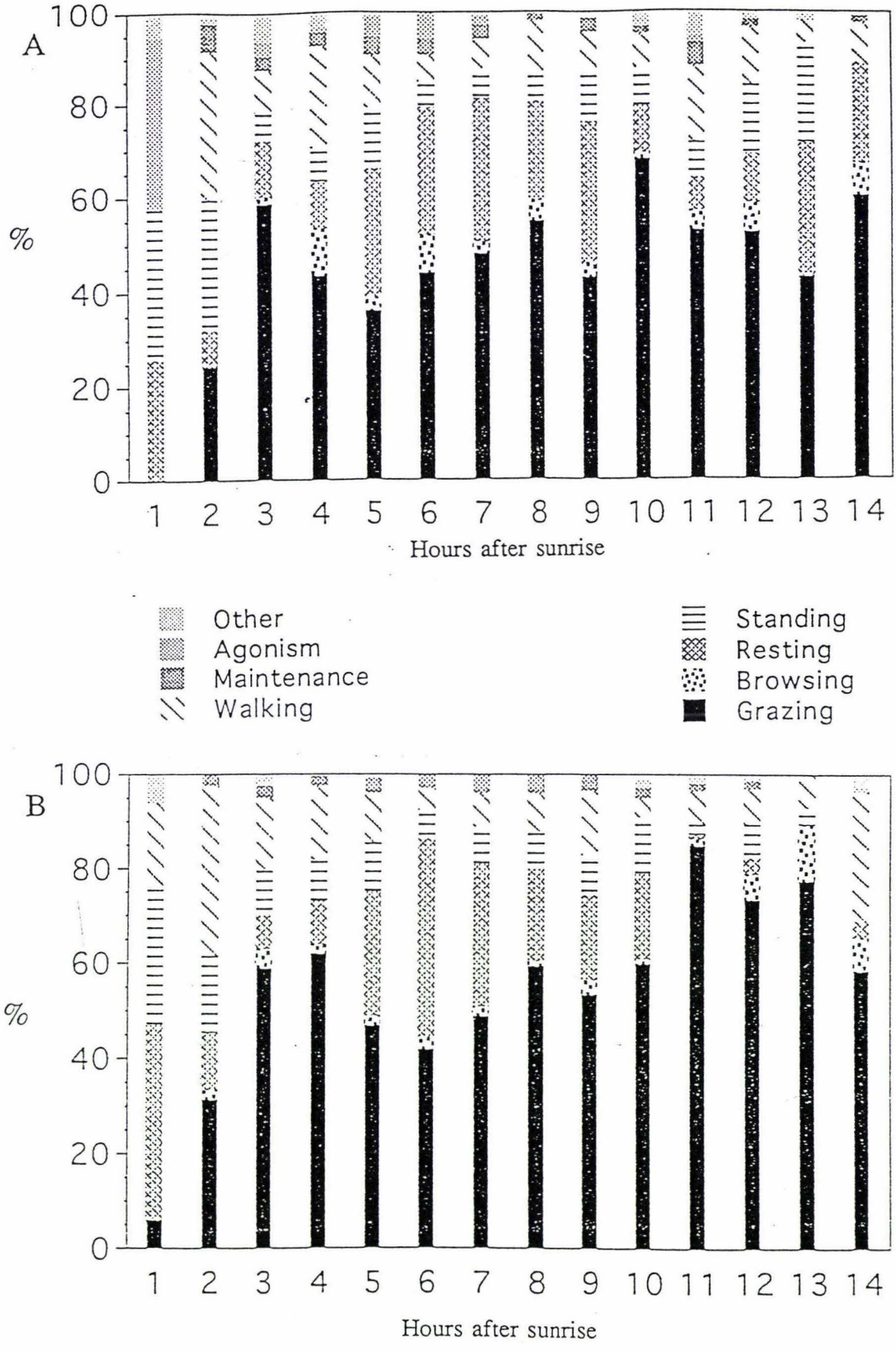
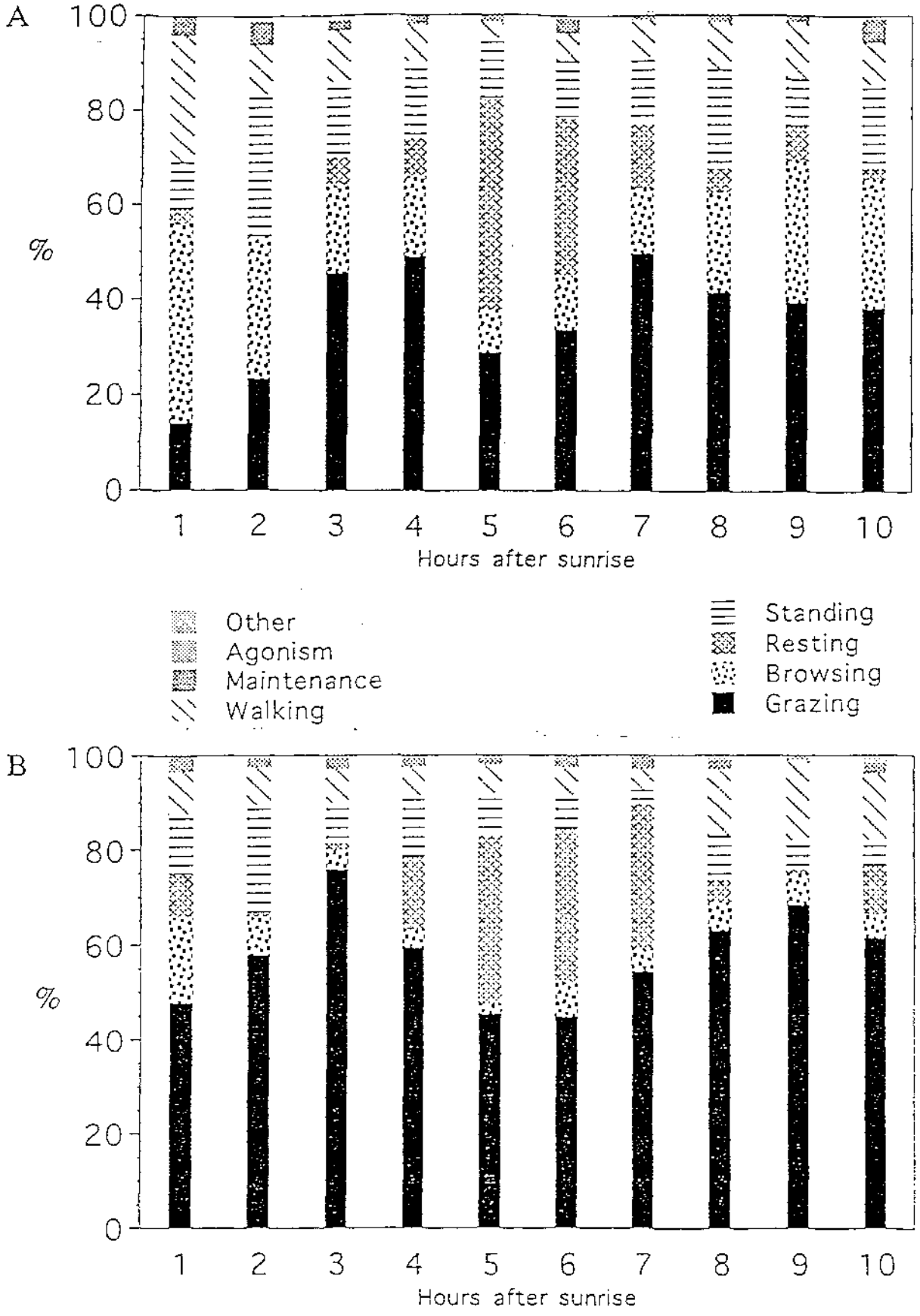


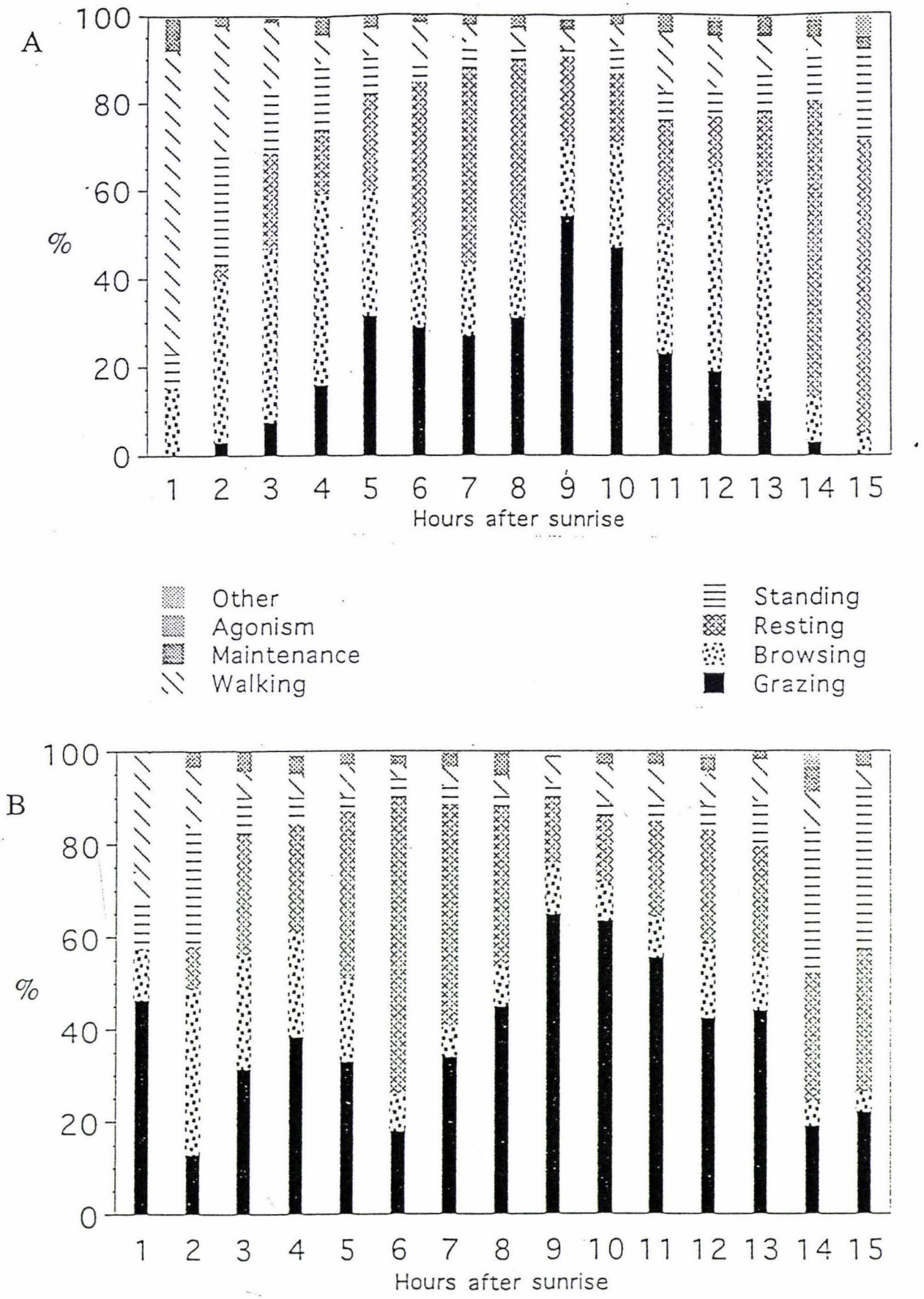
Figure 3.1. Seasonal proportion of grazing and browsing by male and female feral goats (March 1992 - February 1993) in the Mahoenui giant weta reserve. Male grazing (MG), Female grazing (FG), Male browsing (MB) and Female browsing (FB).



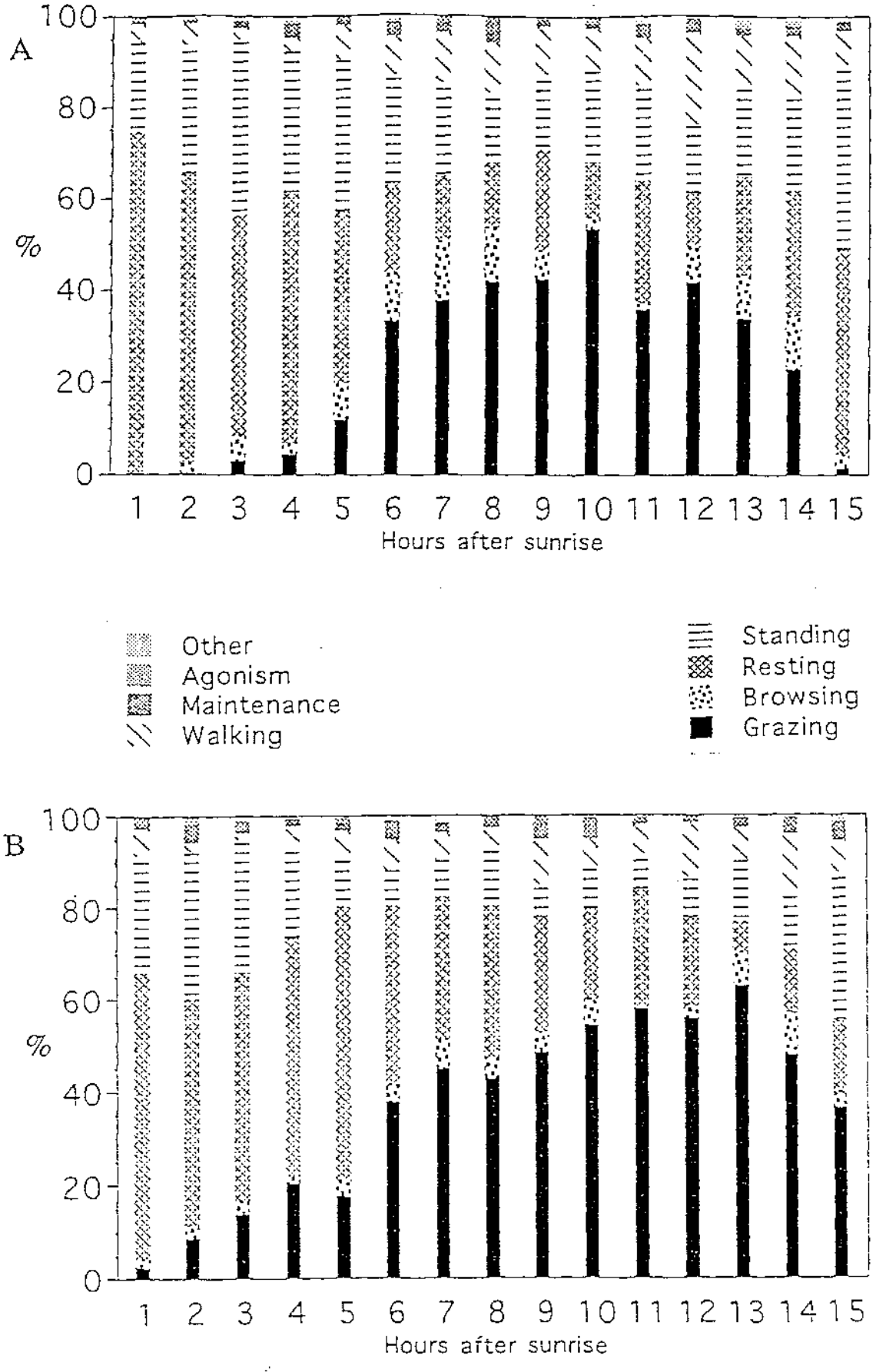
Figures 3.2a and 3.2b. Daily activity budget for male (A) and female (B) feral goats at the Mahoenui giant weta reserve during autumn (n= 3459 male : 4271 female).



Figures 3.3a and 3.3b. Daily activity budget for male (A) and female (B) feral goats at the Mahoenui giant weta reserve during winter (n= 2896 male : 3031 female).



Figures 3.4a and 3.4b. Daily activity budget for male (A) and female (B) feral goats at the Mahoenui giant weta reserve during spring (n= 4132 male : 3825 female).



Figures 3.5a and 3.5b. Daily activity budget for male (A) and female (B) feral goats at the Mahoenui giant weta reserve during summer (n= 5372 male : 4749 female).

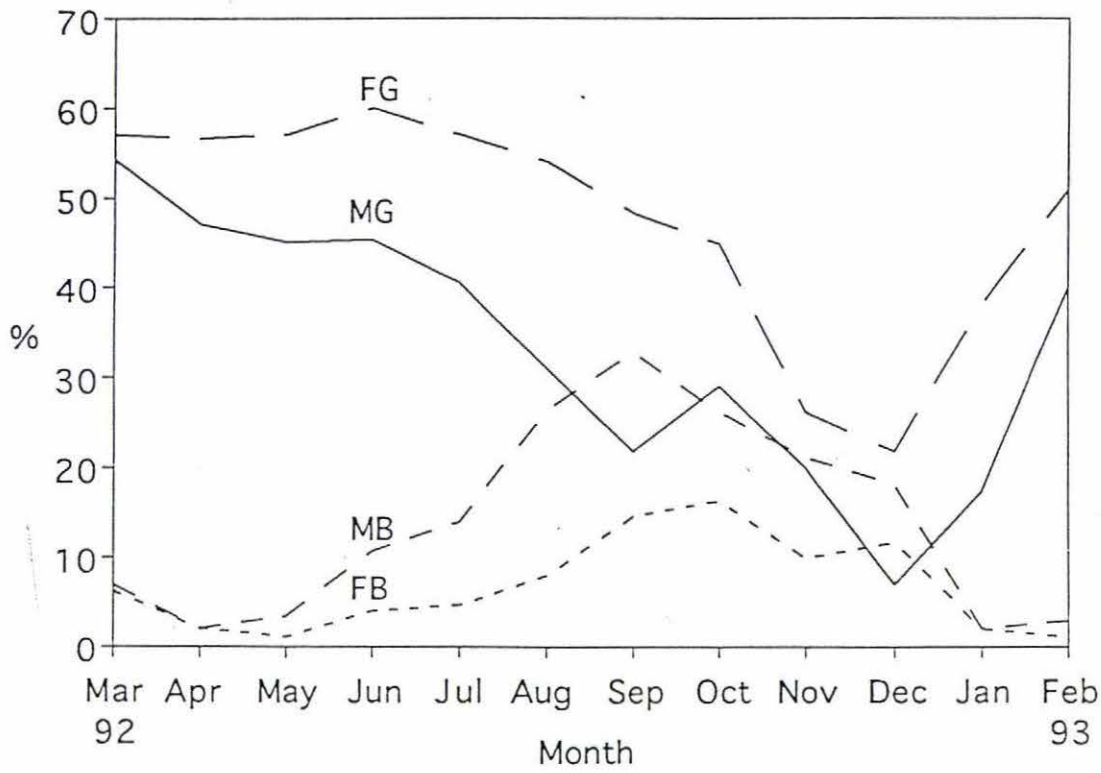


Figure 3.6. Monthly feeding pattern for male and female feral goats (March 1992 - February 1993) in the Mahoenui giant weta reserve. Male grazing (MG), Female grazing (FG), Male browsing (MB) and Female browsing (FB).

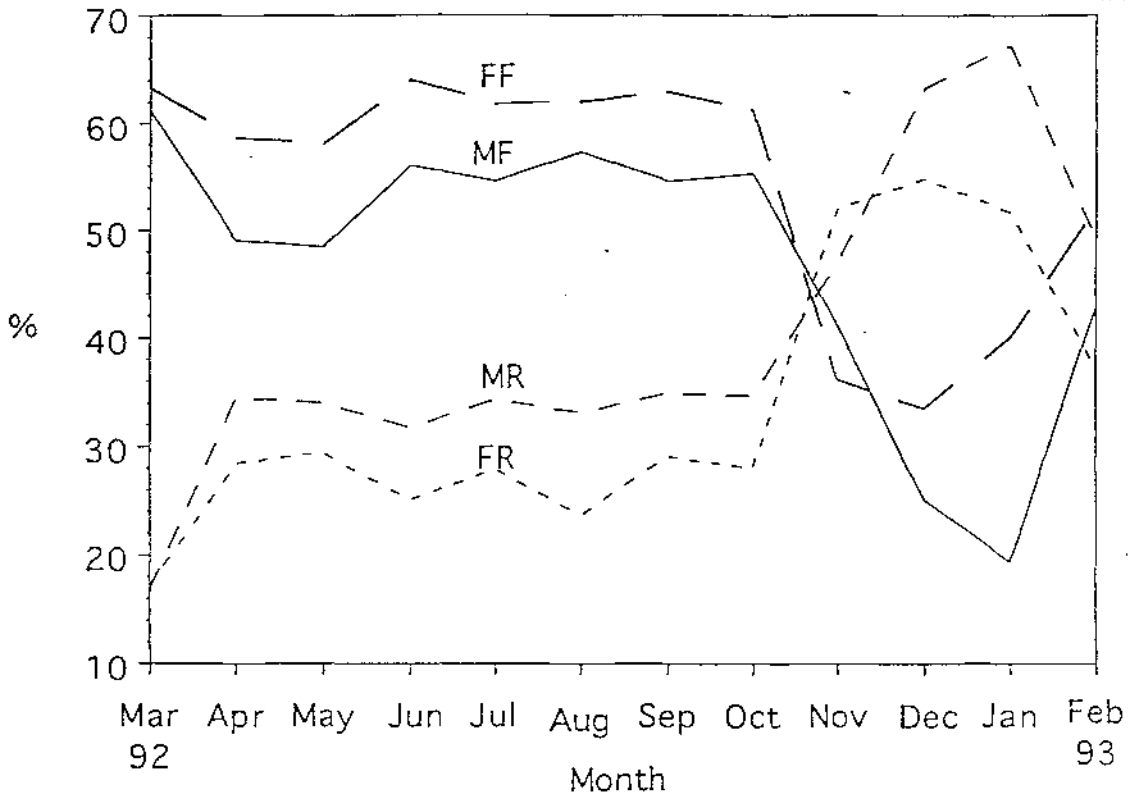


Figure 3.7. Frequency of feeding (grazing and browsing) and resting by feral goats (March 1992 - February 1993) in the Mahoenui giant weta reserve. Male feeding (MF), Female feeding (FF), Male resting (MR) and Female resting (FR).

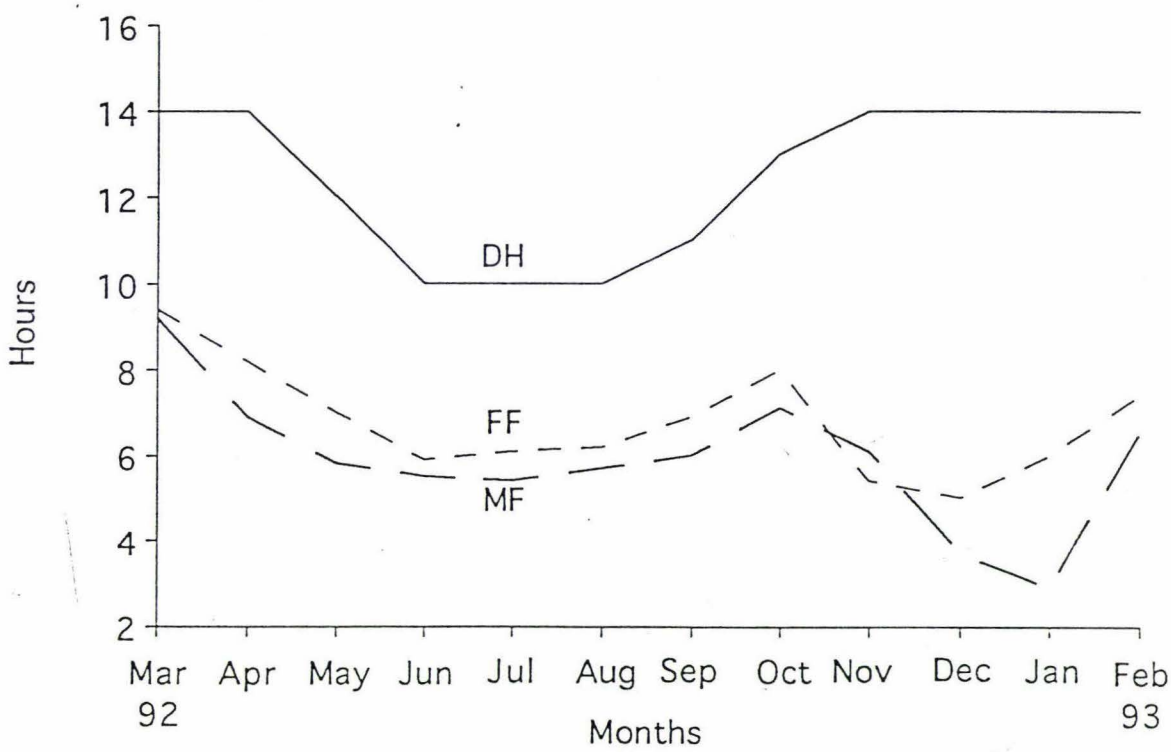


Figure 3.8. Proportion of the day spent feeding by male and female feral goats (March 1992 - February 1993) in the Mahoenui giant weta reserve. Average daylight hours per month (DH), Male feeding (MF) and Female feeding (FF).

again during spring and summer (39% and 35% respectively)(Fig. 3.1). During the day female grazing was bimodal from autumn, through to spring, but showed more distinct peaks than the males. In summer female grazing increased during the day to peak in mid/late afternoon (Figs. 3.2-3.5).

3.32 Browsing

Overall males spent 13% of their time browsing. Browsing increased from autumn (4.5%) through winter (17%) to peak in spring (26%) before declining to 6.5% in summer (Fig.3.1). During winter and spring browsing was highest during the first few hours of the morning and the last few hours before sunset. However in summer and autumn when males browsed least the activity was more constant throughout the day (Figs. 3.2-3.5).

Through the year females spent 6% of their time browsing and followed the same pattern of browsing as males with a peak in spring (Fig.3.1). During this season browsing mostly occurred in the morning. In the other three seasons browsing occurred more evenly throughout the day (Fig. 3.5 and 3.6).

3.33 Intensity of Feeding

Figures 3.9 and 3.10 show the intensity of feeding events by both sexes within the home ranges of the male and female herds as outlined in Chapter 2. Each diagram is based on 14 sample areas where goats were observed feeding. Adjacent areas of similar intensities of feeding events were combined to form one larger area of the same intensity. Use of the range differed between seasons, apparently in relation to the topography. Most feeding events occurred in the valley rather than on the higher, more exposed, hillside.

Use of the valley by males for feeding, increased from autumn to a high in winter and spring. Feeding events outside the valley area were infrequent. During summer and autumn feeding events outside the valley area increased although the majority of feeding still occurred in the valley. Like the males, female goats also utilised the valley for feeding and followed a similar seasonal pattern of movement. But although male and female goats fed mainly in the valley, their usage of the entire range for feeding varied, with one sex utilizing some areas more than the other.

Figure 3.9. Intensity of feeding events by male feral goats within an area of the range occupied by both male and female herds in the Mahoenui giant weta reserve (March 1992 to February 1993). ☐ 0 feeding events; ⁘ 1-10 feeding events; ||| 11-50 feeding events; ### 51-100 feeding events; +++ 101-250 feeding events; △△ 251-500 feeding events; /// 501-700 feeding events; ▩ 701-900 feeding events. (Contour lines are at 20m intervals).

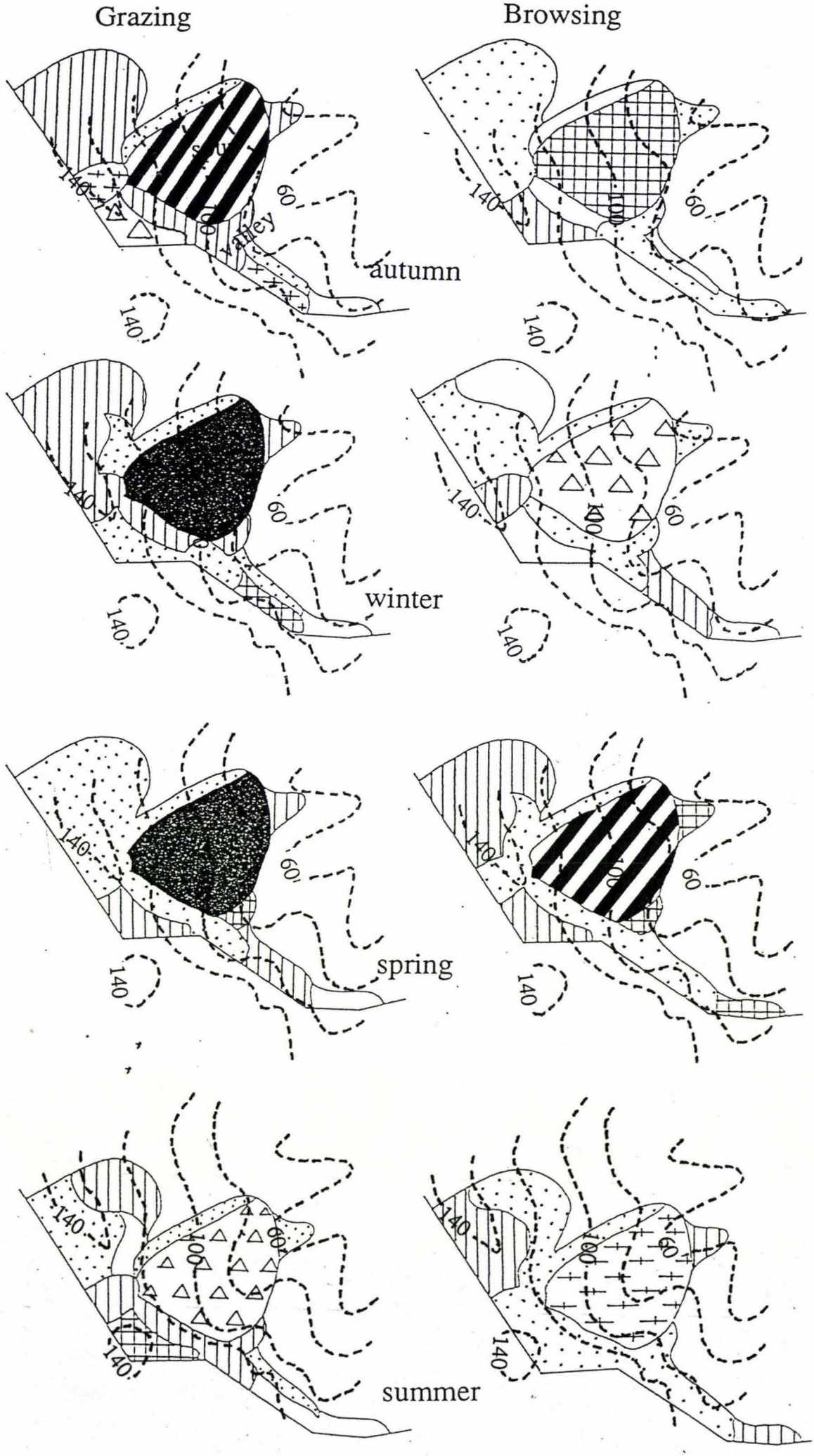
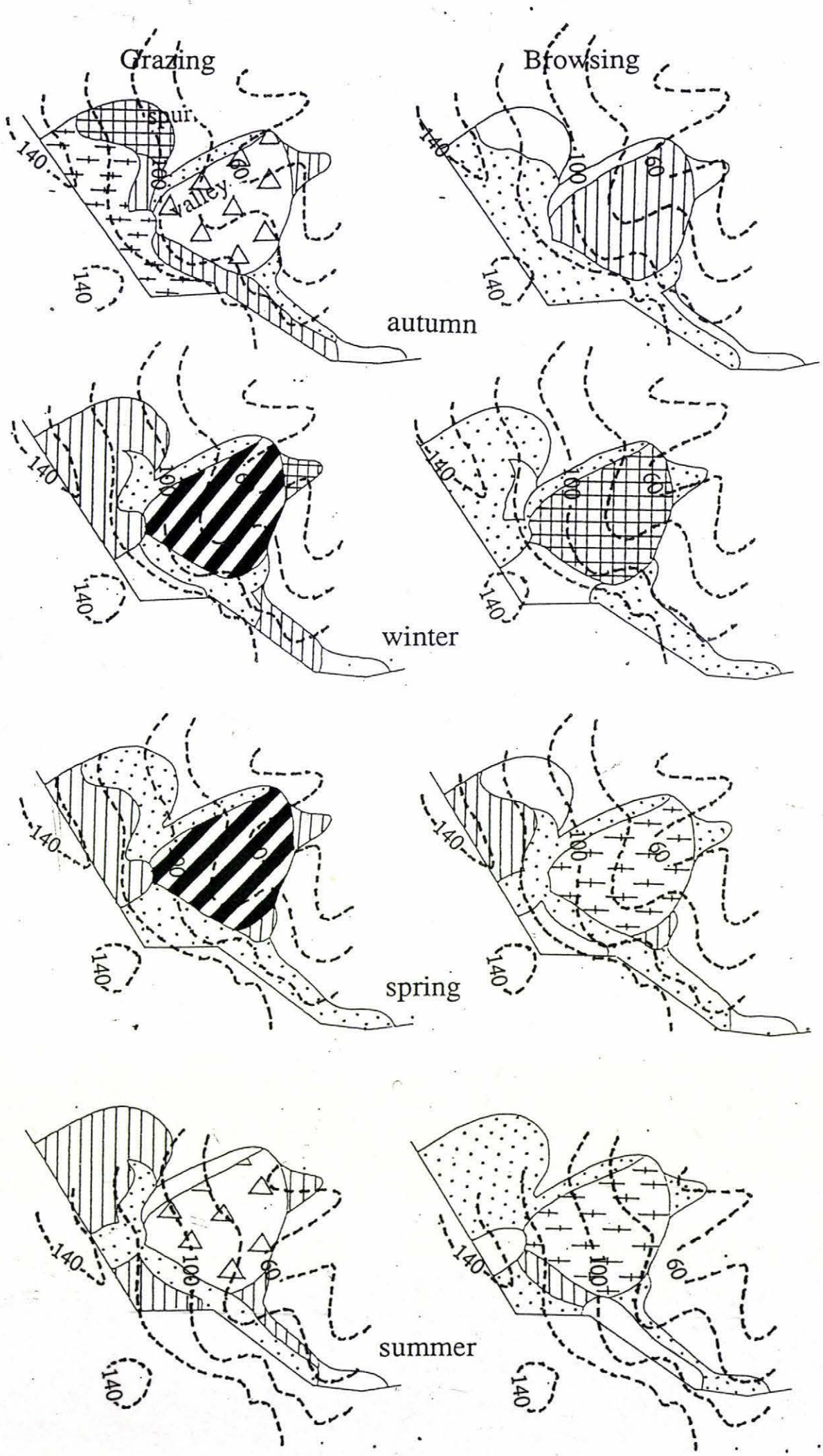

Grazing
Browsing
autumn
winter
spring
summer
140
60
100

Figure 3.10. Intensity of feeding events by female feral goats within an area of the range occupied by both male and female herds in the Mahoenui giant weta reserve (March 1992 to February 1993). ☐ 0 feeding events; ⁘ 1-10 feeding events; ||| 11-50 feeding events; ## 51-100 feeding events; + + + 101-250 feeding events; △ △ 251-500 feeding events; /// 501-700 feeding events; ■ 701-900 feeding events. (Contour lines are at 20m intervals).


Grazing
Browsing
spur
valley
140
100
60
autumn
winter
spring
summer

3.34 Resting

Over the year males spent 28% of their time resting, which was the most frequent activity after feeding (grazing and browsing) (Table 3.1). From autumn to spring resting was most frequent in the middle of the day, and again before dusk (when grazing and browsing were usually least frequent). During summer, however, resting was the dominant activity of males in the first four to five hours of the morning, and again in the last two to three hours before dusk (Fig. 3.2- 3.5).

Female goats spent 25.5% of their time during the year resting and, as for males, this was their second biggest activity. Female resting followed the same seasonal and diurnal patterns as that shown by the males (Fig. 3.2-3.5).

Over the twelve month study period, resting in both sexes increased as time spent grazing decreased, despite the increase in browsing shown by both sexes during spring (Fig. 3.6). Resting reached its maximum during summer for both sexes when feeding was at its lowest (Fig. 3.7).

3.35 Standing

Males and females stood 28% of the time during autumn, spring and summer, and mostly in the early morning and late afternoon. In winter, however, standing in both sexes was spread evenly through the day (Figs. 3.2-3.5).

3.36 Maintenance

Time spent on this behaviour was the same (2.7%) for both male and female and was constant through the day.

3.37 Agonism

Agonism was rare (<1%) but was most common between males from January to March when they competed for access to females. Among the females aggression was directed mainly at foreign kids, and other does, and occurred mainly when groups had gathered to rest.

3.38 Sexual Activity

Sexual activity was observed infrequently over the year, but most events

occurred in late March 1992 (67% n=94) and in January 1993 (20% n=94). But evidence from the presence of kids and the known gestation period (150 days) point to breeding being continuous throughout the year.

Plate 12. Male feral goat (R1) grazing in the south-west corner of the Mahoenui giant weta reserve (March 1992). Note the distinctive coat pattern that aided the identification of some individuals.

Plate 13. Male feral goat (1H) browsing in the south-west corner of the Mahoenui giant weta reserve (December 1992). Note the animal has a gorse stem in its mouth and is about to pull it off the bush. Also note the broken right horn which was used to identify this animal.

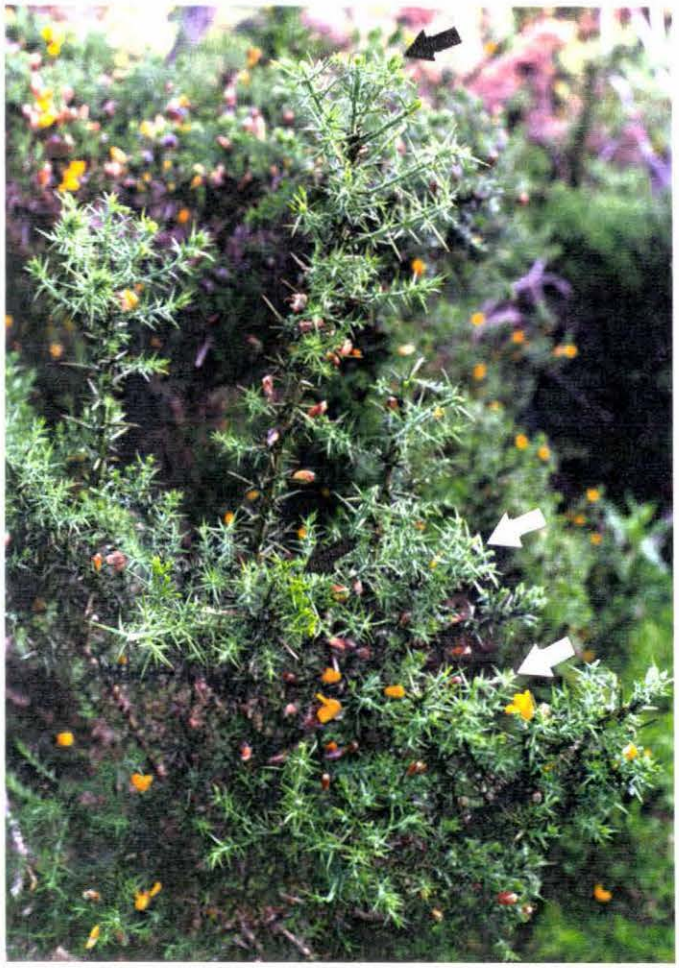


Plate 14. Signs of goat browsing on gorse (March 1992). The black arrows indicate feeding only minutes old. The white arrows show signs of earlier feeding events (Photo : R.Fordham).

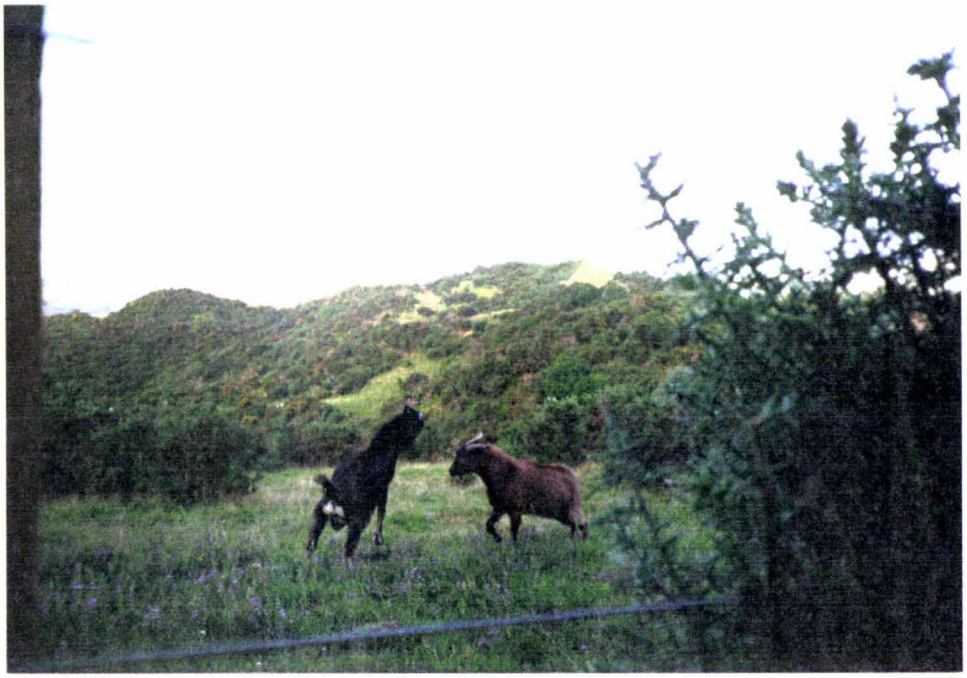


Plate 15. Two male feral goats fighting during the rut in the Mahoenui giant weta reserve (March 1992). Agonism was most common between males from January to March when they competed for access to females. Note the individual on the right is B♂.

3.4 Discussion

Most grazing ungulates feed in the early morning and again in the late afternoon, and rest or ruminate in the intervening period (Lickliter 1987). Goats, however, are neither exclusively grazers nor exclusively browsers (Lu 1988), but occupy an intermediate position (Hofmann 1985). Even so a bimodal rhythm of feeding has been observed in goats (Kilgour 1980; Batten 1983; Brindley et al 1989; Alley 1991), and was seen in the Mahoenui goats during all seasons except summer (Figs. 3.2-3.5). Feeding patterns were more distinct in the females than the males. Females were usually the first to leave bedding sites in the mornings to begin feeding, whereas the last animals to leave were almost always males. The nutritional requirements of gestating and lactating females is large (Rumble 1985; Flowerdew 1987) and may explain why females were quicker to begin feeding each day than males.

During summer feeding increased gradually to a peak in the afternoon. Warmer temperatures at this time of the year associated with reduced reproductive demands on the females, means that energy requirements are lower. Similar reasons would explain the same trend in male feeding. The lack of reproductive demands throughout the year could account for the less distinct feeding oscillations found in diurnal feeding patterns in other seasons. Kilgour (1980) suggested that in high summer goats may graze less because they tend to remain in the shade.

Feeding in the first one to two hours of the morning and the last one to two hours before dusk are probably over estimated. This is because the activity of visible goats was recorded, and when goats bedded down they were usually unobservable. The remaining visible goats were, therefore, probably unrepresentative of the herd and feeding oscillations were slightly biased.

3.41 Seasonal Feeding Patterns

There were differences in the seasonal feeding patterns of males and females. Females spent more time grazing than males in every season, but males browsed more than females (Fig. 3.1). Differences between the sexes in both the species composition of the diet, and in the quality of the diet, have been reported for a number of ungulate species (Putman et al 1993). Most studies on goats, however, have not examined

variation in the diet between the sexes (Riney and Caughley 1959; Atkinson 1963, 1964; Bullock 1985; Lu 1988; Parkes 1989; Alley 1991; Brockie 1992; Genin and Pijoan 1993). Mitchell et al (1987) found that diet did not appear to vary with sex but Clark (1974) inferred from gut nematodes in autopsied goats that females grazed more than males. Shank (1982) reported differences in the quality of foods consumed by male and female Rocky Mountain Sheep and concluded that these differences did not arise as a result of "preference", but because rams and non-rams (ewes, lambs and yearlings) self-segregated onto portions of the range containing distinct forage plants. Staines et al (1982) found that sexual dietary differences were maintained among red deer, even in populations where stags and hinds occurred sympatrically. Stags and hinds also ate different proportions of the same food species, for instance hinds took more grasses than did stags.

Dietary differences are most pronounced in dimorphic species. Illius and Gordon (1987) showed that, other things being equal, weight differences > 20% between males and females would be expected to lead to exclusion of the larger animals from swards where grazing pressure had reduced sward height to some critical level. Therefore females would be able to graze more economically on swards where the standing crop was low, whereas the larger males would be unable to obtain enough food for their nutritional requirements from the same sward. Because of the allometric relations of bite size and metabolic requirements to body size, small animals are able to subsist on shorter swards than large animals (Illius and Gordon 1987). This causes the larger males to turn to other foods in order to obtain sufficient nourishment. At Mahoenui, gorse was the main alternative for bucks.

Where habitat segregation occurs between the sexes in grazing ruminants, males occupy the poorer quality habitats (Geist and Petocz 1977; Staines et al 1982; Bowyer 1984; Clutton-Brock et al 1987; Illius and Gordon 1987; Putman et al 1993). Putman et al (1993) further argued that if such an explanation is valid, we should find similar dietary differences between the sexes in other ungulate species where dimorphism exceeds 1:1.2. Using the bodily weights given by Rudge (1990) for autopsied feral goats throughout New Zealand, males outweigh females by 1.3 to 1.85 times. As discussed earlier bucks and does at Mahoenui occupy overlapping home ranges, which may account for some differences in their feeding patterns. Specifically, the greater use of

browse by bucks may be imposed on them by the presence of the does.

Another influence on seasonal trends in the pattern of foraging may be the annual cycle of sexual activity. In his study on goats in the southern King Country, Clark (1974) found that feral goats have a distinct breeding season, with the maximum number of conceptions occurring in January. This is consistent with the Mahoenui herd where sexual activity was also observed in January, corresponding to the annual minimum in male feeding. During this time males actively pursued females, often disturbing their feeding. Males also spent less time feeding while they were competing for access to the does. During the height of rutting in summer, bucks spent significantly less time feeding than at other times of the year. A direct consequence of this is that they are in poor condition by autumn (Dunbar et al). Does do not decrease their feeding by as much, or for as long, as do the bucks. Although they were pursued and disturbed from feeding by roaming males, once they had conceived, and were no longer in oestrous, females were usually unmolested by males.

In all seasons females spent more time feeding (grazing and browsing) than males and this is probably a result of the nutritional demands of their reproductive physiology. Food intake generally increases during pregnancy and lactation (Flowerdew 1987) when the nutritional demands are high. Does in the last four weeks of pregnancy have nutrient requirements which are 1.5 times higher than does in anoestrous. Overall nutritional demands on does are greatest in the first six weeks of lactation when the requirements are around 2.5 times more than the non-pregnant state (Rumble 1985).

Following peak conception in January and a gestation period of about 150 days (Peaker 1978) most kids were born in June. The time females spent feeding increased from February to a peak in June, then remained high during the following months while females were lactating (Fig. 3.6). However, although time spent feeding was high during this time, the proportion of the day spent feeding did not change during autumn through to late spring (Fig. 3.8). This meant that as day-length decreased the total daily intake would also decrease if no change in either bite rate or bite size occurred (Brindley et al 1989). Peinado-Lucena et al (1992) found that the intake of grass per mouthful varied widely from season to season, with minimal values recorded in winter, increasing to a maximum value in spring. Therefore total daily feeding time and hence total daily intake would be less during winter when the nutritional demands of the female would

be greatest. Liveweight loss due to nutritional deficiencies could result in abortion, and birth of small weak kids. It could also lead to lower reproductive performance in the next season, since the rate of ovulation is dependent on liveweight (McGregor 1990). Feed restrictions during pregnancy has been reported to affect not only fetal size but also birthweight and therefore neonatal growth rate (Osuagwuh 1992). Of seven females observed at Mahoenui, one female lost her kid before weaning and one female was never observed with a kid.

3.42 Intensity of Feeding

Figures 3.9 and 3.10 show the location of feeding that occurred within the area occupied by the male and female herds described in Chapter 2. The size of the sample areas did not appear to affect the intensity of use by goats. Some areas had higher intensities of feeding events than others even though the area was small. Average density is only partly relevant to understanding the effect on habitat of a social species such as the goat. Even at low densities, goats concentrate in, and exert significant pressure on, a few favoured areas (Parkes 1989).

Both Figure 3.9 and 3.10 show that the intensity of feeding varies during the different seasons and that some areas are used much more heavily at some times of the year than at others. The greater use of the valley by both sexes, especially during winter and spring, is probably due to topography and vegetation cover. The topography, along with the greater gorse cover in the valley would provide better protection from the elements during bad weather. In bad weather goats remained in the valley all day, whereas, on fine days they would move across the valley with the sun, always feeding on the sunny side of the valley during the day and moving up onto the ridges in the afternoon when the sun was low on the horizon and the valley bottom was in shadow.

Male and female goats used the available range in different ways. Some areas that were used extensively by one sex were not used by the other to the same extent. Areas that were grazed heavily by goats were not always browsed heavily, and vice versa. Observed differences in the way males and females feed in parts of the range, where resources were apparently equivalent, agrees with the model of Illius and Gordon (1987). This model predicts the level of dietary competition between the sexes from the relationship between body mass and bite size. If no such difference existed we would

expect to see similar use of the range for feeding by both sexes.

3.43 Effects of Domestic Cattle on Goat Feeding

Approximately 105 head of domestic cattle (in calf Angus and Hereford/Angus x) were introduced to the reserve in August 1992 from a neighbouring farm, and allowed to graze there with their calves until January 1993. Upon introduction the cattle initially grazed near the reserve gate. Over a period of weeks they slowly moved down the fire breaks towards the river, and finally into the bottoms of the valleys (N. Rauputu pers. comm.).

The introduction of cattle to the reserve appeared to have little effect on goat feeding. Differences in feeding styles between goats (selective grazers) and cattle (non-selective grazers according to Hofmann (1985)) would allow for both species to exist on the same sward for a time. Studies on grazing succession in the African Savannah ecosystems show that large species (non-selective grazers) are the first to migrate from swards grazed short in the dry season (Vesey-Fitzgerald 1960; Gwynne and Bell 1968; Bell 1970; McNaughton 1984; Illius and Gordon 1987). From this we would expect that cattle become nutritionally stressed before goats when grazing the same sward. This could be seen at Mahoenui where cattle dispersed in a slow wave through the reserve, successively grazing clearings of rough pasture. In contrast the goats remained faithful to their home ranges grazing the same clearings day after day, even when cattle had already been through. If cattle were to affect goat grazing then the effects would be most evident in females because they spent more time grazing than males. No such trend was observed. However, cattle grazing did appear to affect male feeding. After the cattle were introduced males began browsing more, until browsing occurred more frequently than grazing (Fig. 3.6). Possibly males were already under pressure from the smaller females when grazing preferred swards, and the further reduction of sward height by cattle made it even harder for the males to meet their nutritional needs by grazing.

Cattle may also be of benefit to feeding goats. Cattle help to break down gorse by forcing passages through it en-route to grazing. By so doing they help to give goats access to gorse trees, and allow direct light penetration to lower levels, stimulating new green growth. Thus cattle enable goats to better exploit gorse trees (Sherley 1992).

Cattle may also be beneficial to goat health and production. Integrating cattle and goats results in better pasture quality than with goats alone. "Goat sick" pasture is likely to result from grazing goats in isolation because herb weeds start to dominate and so pasture quality deteriorates. Trials run at the MAFTech Whatawhata Research centre have shown that doe liveweight gain in an integrated grazing system was almost twice that of a goat-only regime (Anon 1981).

3.44 Resting/Standing

In the Mahoenui goats there was little difference in the amount of time males and females spent resting. However when combined with standing, bucks spent more time throughout the year at this activity than does. This is consistent with the consumption by males of lower quality forage and their probable need, therefore to spend more time ruminating than females grazing higher quality pasture.

The November increase in resting seen in both sexes corresponded to a decrease in feeding. For both males and females the peaks in resting coincided with lows in feeding (Fig. 3.7), and with the onset of sexual activity. Rising ambient temperatures and improved quality of feed during spring would also affect the amount of time spent resting by goats. The energy needs of mammals are lower during warmer weather. However the demands of reproduction especially on the males during summer may greatly outweigh this benefit.

The difference in the amount of time goats spend standing in winter, compared with the other three seasons, may be due to the weather. In winter, time spent standing was more consistent throughout the day compared to the other three seasons when standing was greater in the morning and late afternoon/early evening. Goats usually react adversely to rain (Brindley et al 1989), by seeking shelter. In winter rain was frequent at Mahoenui (Appendix 1) and goats were often seen standing under gorse bushes during the showers. At such times they did not feed or carry out bodily maintenance activities.

3.45 Agonism

Interactions between males were most frequent during mating (January-March) when intense competition for access to females occurs (Dunbar et al 1990). Outside this

period very little agonism between males was observed. Instead the males formed close associations in the form of bachelor herds where they fed, travelled and rested together without any overt signs of antagonism.

Female agonism occurred more consistently throughout the year and was directed mainly at foreign kids and conspecifics as described by Alley (1991) and Maestripieri (1992).

3.46 Sexual Activity

All studies of feral goats in New Zealand show virtually year-round breeding, with one, sometimes two, distinct peaks (Rudge 1990; Parkes 1992). Clark (1974) found for goats in the southern King Country that breeding peaked over summer. Maximum conceptions occurred during January and there was a secondary peak in March/April. The Mahoenui pattern was similar, with sexual activity through January in 1993 and also in March (1992).

Like other feral populations, the Mahoenui goats bred at all times of the year. Of seven known females in the study area, four kidded in June or July, consistent with a peak of mating in January. One female kidded in September (April conception), and one female was already suckling kids during February 1992 and therefore would have conceived during mid-winter. The remaining female was never observed with a kid, and her reproductive history is unknown. Interestingly, this female spent more than twice the average time browsing (therefore consuming lower quality forage) than any of the other known females, and this could have influenced her reproductive success.

Males also exhibited sexual behaviour throughout the year, but only rarely outside the summer season.

Chapter 4

Autopsy Data

4.1 Introduction

Post-mortem examinations are designed to meet many different objectives - to determine the cause of death; to study the relationship between age, sex, location and nutritional state; or any one of several other items (Cowan 1969).

A small sample of goats was shot and autopsied during winter and again in summer to obtain an approximate comparison with diet as revealed by direct observation. In addition to this information, data on animal condition were collected, because the condition of wild ungulates is primarily a function of the balance between population density and the availability of food (Challies 1989). Reproductive information was collected to help describe the breeding status of the population.

4.2 Methods

Goats were shot and autopsied in July 1992 and February 1993 for rumen analysis (five goats were also shot in June 1992 but only data on age and reproductive status were collected). Efforts were made to obtain equal numbers of males and females, but because of the difficulty of obtaining animals the ideal 1 : 1 ratio was not achieved for the winter sample. 34 goats were collected overall (n=20 winter, n=14 summer).

Autopsies followed Mitchell (1985) and involved;

(1) Recording the date, time of death, location in the reserve, sex and jaw tag number.

(2) Removal of one half of the lower jaw for ageing by tooth eruption sequence (Holst and Denney 1980; Rudge 1990).

(3) Recording the reproductive status of females, and;

(4) Collection of rumen contents from different regions of the rumen. This material was stored in numbered 500ml plastic jars containing 50mls of 100% formalin.

Processing the rumen samples involved;

(1) Standardising each sample to 200mls and soaking this sample in water for several

hours to remove the formalin.

(2) Sieving each standardised sample through a 4mm sieve (Parkes 1984b).

(3) Identifying the remaining fragments. This was achieved by placing the sample into an opaque perspex tray containing water to diffuse the plant fragments. The tray was placed over a light box to highlight plant fragment characteristics. Fragments were sorted into three broad categories - Gorse; Pastoral grasses and weeds; and Other browse species. A dissecting microscope was used to aid in identification.

(4) Calculation of the percent of each category in the diet. Plant fragments were spread on tissue paper and blotted to remove surface water. The volume of each category was then determined by water displacement in a volumetric flask. These volumes were then converted into percentages of the total amount of identified material in the sample.

4.3 Results

4.31 Rumen Contents

Data from 29 rumen samples (winter n= 15, summer n= 14) show that there is a significant difference in the amount of gorse, grass and other browse in the diet between the two seasons (Fig.4.1). Significantly more grass is eaten during summer (78%) than in winter (42%). During winter there is significantly more gorse (52%) in the diet than in summer (9%).

Figure 4.2 shows the comparison between male and female goats for the rumens collected. During winter no significant difference between the amount of gorse and grass in the diet was found for either males or females. During summer no significant difference was found in the amount of gorse eaten by males and females, nor in the amount of grass consumed. The amount of grass eaten by both males and females is significantly greater in summer than in winter, whereas the amount of gorse consumed is significantly less in summer compared to winter.

There is no significant difference in the amount of other browse consumed, either between seasons, or within seasons for either sex.

4.32 Population Biology

4.321 Age Structure

Age structures for the goats autopsied are presented in Figures 4.3 and 4.4. In both seasons the number of animals in the >1-2 year age class is lower than for the other three age classes. Relatively more animals >2 years of age were shot than those <2 years (Fig. 4.4).

4.322 Reproduction

Of the 33 goats sampled 24 were female. Of the eight females sampled during summer, none was pregnant, however two females (25%) were lactating. Of those sampled during winter (n=16) two females (12.5%) were pregnant and nine females (56%) were lactating. Both pregnancies were single conceptions.

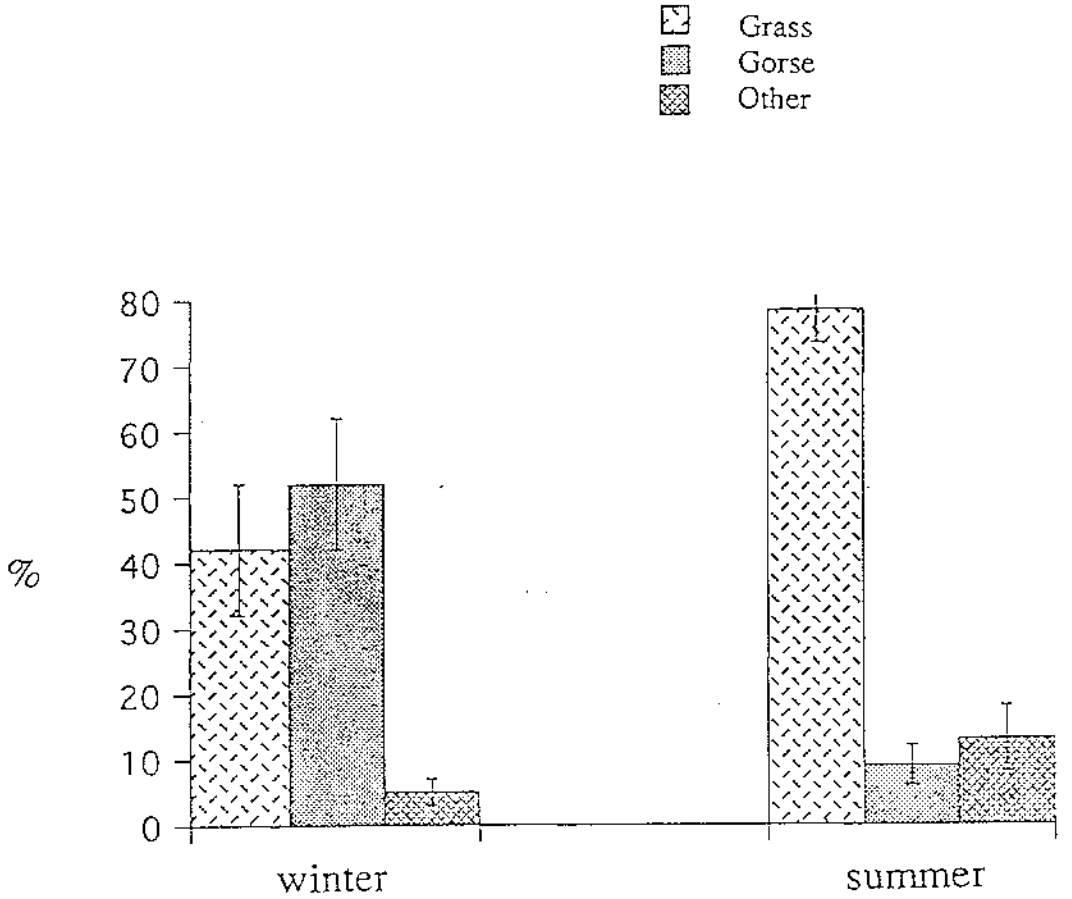


Figure 4.1. Mean percentage of grass, gorse and other browse in the rumen contents of goats autopsied at the Mahoenui giant weta reserve during winter and summer.

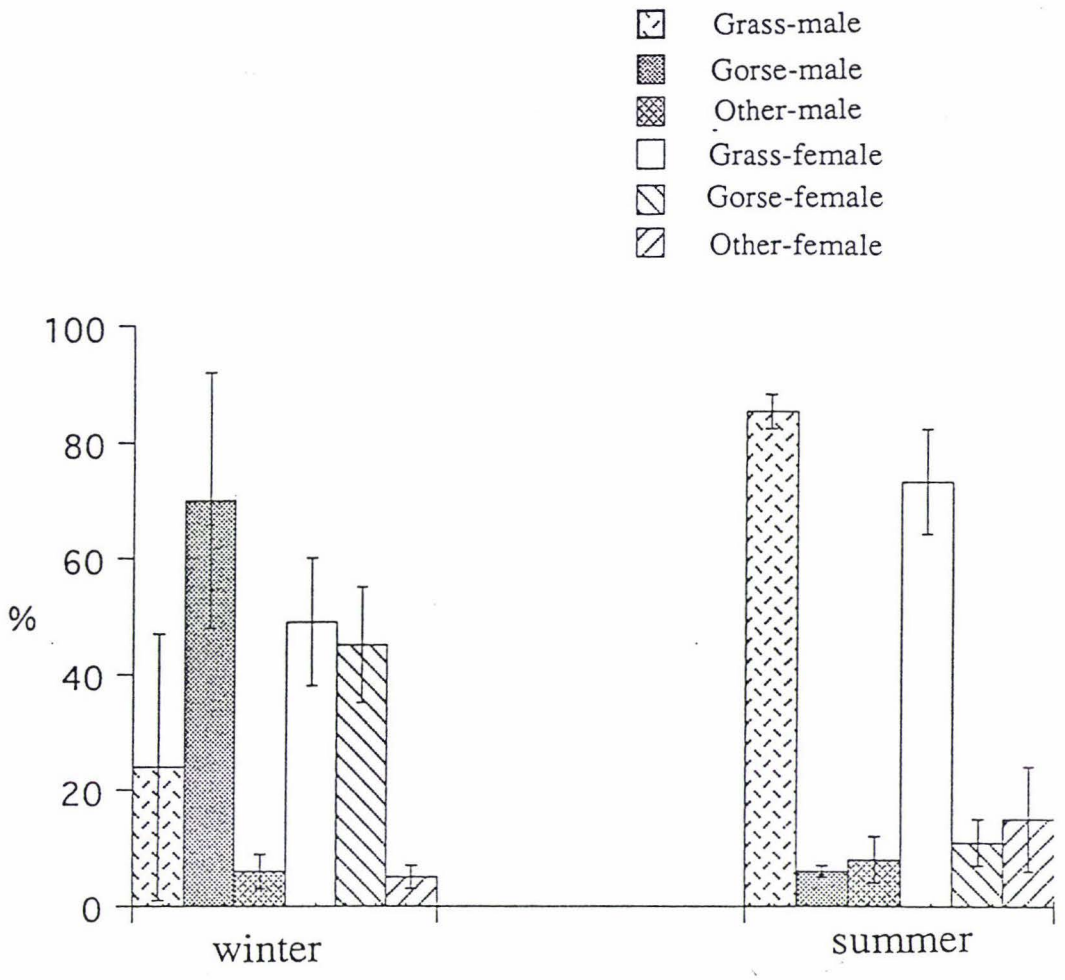


Figure 4.2. Mean percentage of grass, gorse and other browse in the rumen contents of male and female goats autopsied at the Mahoenui giant weta reserve during winter and summer.

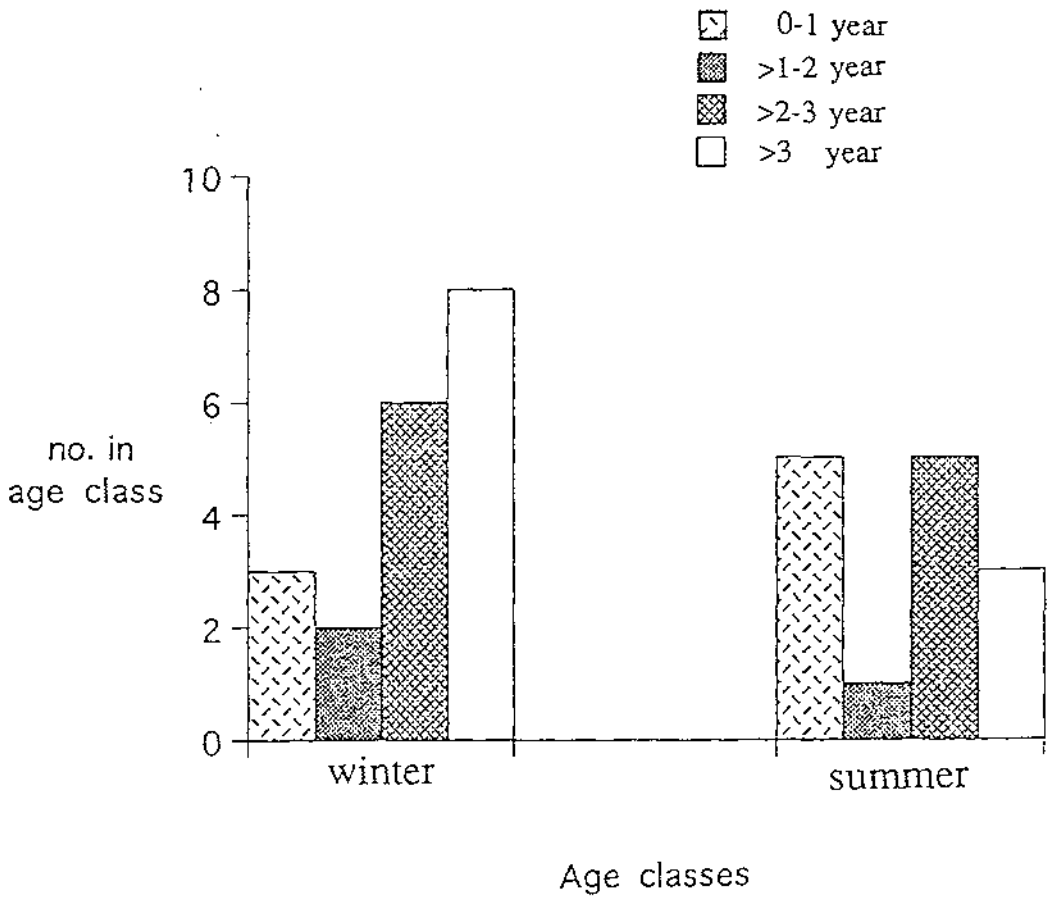


Figure 4.3. Age structure of goats autopsied at the Mahoenui giant weta reserve during winter (n = 19) and summer (n = 14).

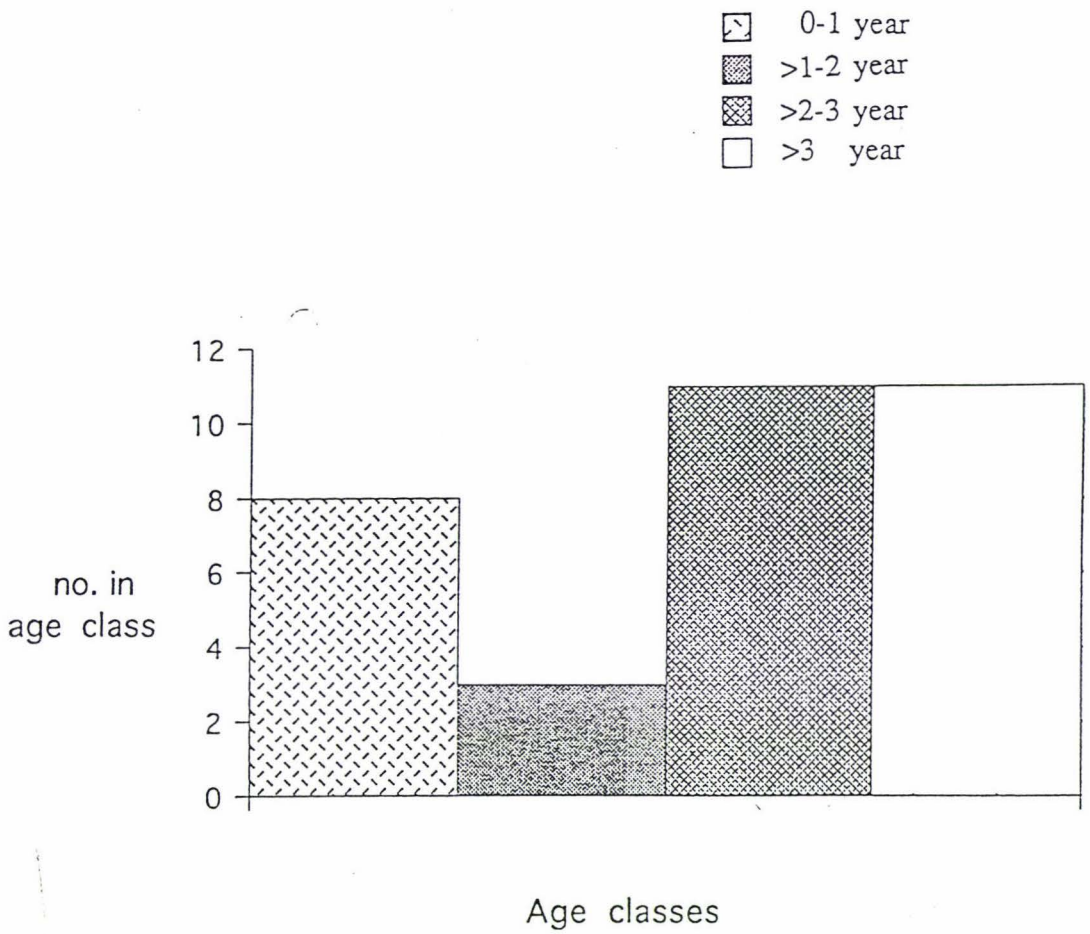


Figure 4.4. Age structure of goats autopsied at the Mahoenui giant weta reserve (n = 33).

4.4 Discussion

4.41 Rumen Contents

Data obtained from analysis of the rumen samples support the data in Chapter 3 on goat feeding.

As found by direct observation grass made up the majority of the diet for both sexes during summer, with gorse being a minor component. During winter however, the percentage of gorse in the diet increased considerably for both sexes while the percentage of grass decreased.

Although analysis of the rumen contents supports the seasonal difference in diet revealed by direct observation it does not appear to support the seasonal differences between male and female feeding. This is probably a result of the sample size. Diet selection is affected by individual variations due to sex and age and also the recent dietary history, and preferences of individual animals (Gaare et al 1977). Therefore the sample size should be large enough to cover any individual variability. But the rumen data are derived from a sample of only 29 individuals (10 male, 19 female) over the two seasons, whereas the direct observations involve 1325 males and 1414 females for the same two months. The small sample size means that the rumen data are variable, however the results do approximate those of the observational data which have a sample size large enough to account for individual variation.

Although the amount of other browse in the diet did not change with season, its composition did. During winter the main component of this fraction was ferns along with some fungi. Rudge (1990) found that ferns were eaten more in winter for goats in the Rimutaka Range. During summer ferns were found in only three samples. During summer willow weed (*Polygonum persicaria L.*) was the main component of the other browse fraction, occurring in 10 of the 14 samples. For one female it made up over 78% of the rumen content.

Studies on goat diet in New Zealand show that goats can eat a wide range of plant species if available. Goats in the Rimutaka Range ate 120 different plant species (Rudge 1990) while Parkes (1984b) identified 42 different species of plants in the rumens of goats collected from Raoul I.. On Mount Egmont individual rumens contained on average 19 species and sometimes over 30 (Mitchell et al 1987). Turbott

(1948) - in Mitchell (1985) found on examination of several rumens that grasses, sedges and herbs made up the majority of the diet for goats on Great I. in the Three Kings group, and concluded that goats had been grazing. However palatable trees and shrubs were eaten to a high browse line implying goats had little choice except to graze. At Mahoenui the high proportion of gorse and grass in the diet may reflect the lack of variety in available food. The few native trees in the area of the reserve that the goats were shot in are mature and well above the goats browse range.

There is considerable evidence that in ruminants learning plays an important role in behaviour and diet selection (Edwards 1976; Keogh and Lynch 1982; Lynch et al 1983; Green et al 1984; Provenza and Malechek 1986; Provenza and Balph 1987; Zahorik et al 1990; Thorhallsdottir et al 1990; Bryant et al 1991; Biquand and Biquand-Guyot 1992), and it is possible that kids learn what to eat, especially gorse, by watching their mothers. One kid, only a few days old, was observed to follow its mother to a gorse bush and watch as she began browsing. The kid then began imitating its mother. In the three months prior to her kidding this female was never observed to browse gorse. Edwards (1976) suggested that moose calves learn what to eat by following their mother and eating the same plants that she eats. Thorhallsdottir et al (1990) found that lambs ate significantly less harmful foods when they observed their mother avoid such foods than when they were exposed to these foods alone.

Learned browsing could have managerial implications for the reserve. On the one hand, learning may result in inefficient foragers when animals are moved to new environments. On the other, through the manipulation of past dietary experience, a manager could create a foraging group that better fits management goals (Provenza and Balph 1987). Therefore if goats are to be used in the management of other mainland gorse habitats for weta ideally they themselves should come from a gorse habitat.

4.42 Population Biology

4.421 Age Structure

Due to the age/sex bias and the low numbers of animals shot overall, the age structure of the sample may not reflect the age/sex structure of the Mahoenui

population. As the observational data was based on adult animals, efforts were made to collect only adults. However, eventually individuals were shot as encountered in order to obtain enough animals. Shooter bias prevailed however, especially during winter (Fig.4.3) when females had just kidded. When mixed age groups were encountered older individuals were preferentially selected.

4.422 Reproduction

The gestation period for goats is 150 days (Peaker 1978). From the goat embryo length/age curve given by Parkes (1984a) the embryos taken from the two females autopsied in winter were approximately 125 and 135 days old. Eleven days separated the time the females were shot so both would have conceived during mid February. This corresponds to the observed mating peak during summer. The high proportion of lactating females in the winter sample also indicates a summer mating peak. Winter births are the norm for feral goats in New Zealand (Clark 1974).

Both females autopsied and five of the six females in the observed herd, had single conceptions. The remaining female observed with kids had twins. One of the lactating females sampled was also observed to have twins, which were not shot. Mitchell (1985) found a high proportion (77%) of multiple conceptions on Mount Egmont, but only 31% of the conceptions on Macauley I. were multiple (Williams and Rudge 1969). Clark (1974) found twinning to be variable in the King country, even within the population. In one area he studied only 5% of the conceptions were multiple, whereas in an adjacent area 23% of the conceptions were multiple.

Due to the low numbers sampled it is uncertain how closely the data collected reflect the actual reproductive history of the population.

General Conclusion

The Mahoenui giant weta reserve in southern King Country is the location of the largest known population of the undescribed Mahoenui weta. Although aspects of the ecology of the Mahoenui giant weta have been researched little attention has focused on the flora and fauna that share the weta habitat, and the ecological effects these species may have on weta survival.

The main woody plant in the reserve is gorse, which provides protection, shelter and food for weta. Goats also browse the gorse so there is a dietary overlap between weta and goats. Gorse could be considered adequate for goat growth at Mahoenui only during late spring/early summer when new foliage appears. At other times of year it is probably no more than a maintenance feed. At their present density of only 1-2/ha goats would not be able to keep gorse growth static. Neither would they prevent the emergence of native tree seedlings. Thus, in the absence of manipulation, gorse may be succeeded gradually by native forest cover, and this may be detrimental to weta survival.

Both male and female feral goats occupied overlapping home ranges within the reserve. Sexual segregation into male and female groups with distinct and separate ranges did not occur, although males did form bachelor herds during winter. Neighbouring ranges overlapped and animals from several ranges occupied common bedding sites during the year.

Feeding (grazing and browsing) was the dominant activity of adult feral goats in the reserve. Females spent more time feeding than males. Grazing and browsing changed seasonally for both sexes, with grazing generally decreasing from autumn to summer, and browsing increasing from summer to spring. In every season females spent more time grazing than males, but males browsed more than females. The greater use of browse by the bucks may be imposed on them by the presence of the does.

Resting was the second most important activity after feeding, and when combined with standing, males spent more time in this activity than females. This is consistent with the consumption by males of lower quality forage and their probable need, therefore, to spend more time ruminating than females grazing higher quality pasture.

Breeding in the reserve occurred year-round, however, direct observation and autopsies indicate that most conceptions occurred during summer.

Overall the goats appear to have little influence on weta. Evidence from observation and autopsies indicate that goats do not endanger weta through their browsing, or by accidental predation. Although goats shape gorse into dense bushes which may provide weta with protection from predators such as rats, the percentage of these bushes in the reserve is small, with most of the gorse in the reserve consisting of large open bushes.

Goats have probably reduced the rate of emergence of native tree seedlings and hence slowed the successional change from gorse to native forest cover. This in itself is probably the most important role that goats have played in the reserve. They can not however, on their own, prevent succession from occurring.

Future Work

Several aspects of this study lend themselves to further research. First, a detailed measure of the structure of the gorse community and the extent of succession to a cover of native species would indicate the risk to weta inherent in this natural process.

Second, the amount of gorse browsing by goats could be examined in areas of the reserve with a higher proportion of native and hence possible alternative feeds. For example, does gorse consumption decrease in areas of mixed gorse/native vegetation? Do goats spend more, or less time browsing in a gorse habitat than in a native habitat such as the remnant forest areas?

Third, it would be useful to quantify the amount of browsing by goat kids and to determine any learned responses to browsing. These questions could be pursued through successive generations. For example, do females that browse a lot raise kids that also browse heavily, and is this behaviour passed on in turn to their kids? Conversely, do females that graze heavily influence their young to becoming mainly grazers? Both these questions would be of benefit in the manipulation of goats for managerial purposes, not only for the reserve, but in a wider agricultural situation.

Fourth, more research is needed into the population structure of the feral goats in the Mahoenui giant weta reserve to aid in future monitoring. Information on the reproductive status of the herds, mortality rate of kids and adults, and the general well-

being of the population is required.

Implications for Management

It is important not only to monitor the weta population and the goat population, but also the community structure of the vegetation in the reserve. Although they have not prevented it, goats have probably slowed down the rate of succession to native vegetation in the reserve. Goats can be used to crop weeds, such as gorse, and by keeping growth static thereby maintain the resource. However this requires higher goat densities than at present, manipulation of the herd, and farm management techniques which are not possible with a feral herd. Mechanical disturbances, such as felling gorse also prevents succession, prolonging the dominance of the species, by favouring the establishment of dense young gorse.

Integrating these two systems (keeping the feral herd as is and using planned, periodic mechanical disturbances), may help to maintain the gorse habitat on which the Mahoenui giant weta has come to depend. It is therefore recommended that as part of the overall management plan for the Mahoenui giant weta reserve monitoring systems for the feral goat population and the vegetation community structure be put in place.

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Appendix 1

Monthly rainfall from Te Kuiti (40 km from Mahoenui) and from Pureora Forest (approximately 60 km from Mahoenui) for February 1992 to February 1993. Pureora Forest data is included due to gaps in the Te Kuiti records. Data were recorded by the New Zealand Meterological Service (dash (-) = no data available).

Month	Total Rainfall (mm)	
	Te Kuiti	Pureora Forest
February	79.5	158.0
March	-	113.0
April	76.4	65.8
May	-	66.0
June	113.4	127.9
July	238.0	279.7
August	270.5	295.2
September	136.2	171.3
October	224.2	170.9
November	94.8	113.3
December	-	180.7
January	59.7	78.4
February	69.3	84.3